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NATIONAL PRIORITY LIST
U.S. DOE HANFORD 100 AREA

AUGUST 17, 1987

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NPL CANDIDATE
Update #
Received SEP 1 4 1987

Facility name: U.S. DOE Hanford 100 Area

Location: Hanford Site

EPA Region: X

Person(s) in charge of the facility: J. J. Keating, Asst. Mgr.
Safety, Environment and Security
509 - 376 - 7334

Name of Reviewer: D. M. Bennett, EPA Region X Date: 8-17-87

General description of the facility:
(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)

The 100 Area Site contains the 116-B-4, 116-B-6, 116-C-2, 116-D-1A, 116-D-1B,116-F-5,116-F-10,116-H-3,116-K-2,116-B-1,116-B-3,116-C-1, 116-D-2,116-DR-1,116-DR-2,116-DR-4,116-F-1,116-F-2,116-F-3,116-F-4, 116-H-1,116-H-4,116-K-1,116-K-2,116-B-5,116-B-10,116-C-2,116-D-3, 116-D-4,116-F-9,116-F-13,116-B-2,116-D-1A,116-D-1B,116-DR-3,116-F-3, 116-KE-3,116-KW-2,116-DR-6,116-F-1,116-F-6,116-F-12,116-H-2,116-K-2, 116-DR-8,116-F-7,117-B,117-C,117-D,117-H,100KE*1,100KE*2,100KE*3,100KW*1 100KW*2,116-B-9,116-D-6,116-F-11,116-DR-7,116-KE-1,116-KW-1,116-KE-2, 107-B,107-C,107-D,107-DR,107-F,107-H,107-KE,107-KW, White Bluffs Pickling Acid Crib,118-B-1,118-B-4,118-B-5,118-C-2,118-D-1,118-D-3, 118-D-5,118-DR-1,118-F-1,118-F-3,118-F-7,118-H-1,118-H-2,118-H-3,

Scores: S_M = 46.38 (S_{gw} = 6.12 S_{sw} = 80.00 S_a = 0.00)

S_{FE} = 0.00

S_{DC} = 0.00

QA 1/11/88
Kathy E. Galloway
Revised 1/14/88 KG

FIGURE 1
HRS COVER SHEET

9 1 1 1 8 9 7 9 9 5 0

118-H-4, 118-H-5,188-K,118-B-2,118-B-3,118-D-4,118-F-1,118-H-3, 118-B-6,118-F-5,118-F-6,118-B-1,118-B-7,118-C-1,118-D-1,118-D-2, 118-F-2,118-F-4,118-H-1,118-K,100B/C Burn Pit,100DR Burn Pit,100F Burn Pit,100N Burn Pit and 100K Burn Pit sites.

FIGURE 1 (Continued)
HRS COVER SHEET

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HRS Ground Water Route Work Sheet

Site: U.S. DOE Hanford 100 Area 8/17/87

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	45	1	45	45	3.1
If observed release is given a score of 45, proceed to line 4. If observed release is given a score of 0, proceed to line 2.					
2. Route Characteristics					3.2-
Depth to Aquifer of Concern	0	2	0	6	
Net Precipitation	0	1	0	3	
Permeability of the Unsaturated Zone	0	1	0	3	
Physical State	0	1	0	3	
Total Route Characteristics Score			0	15	
3. Containment	0	1	0	3	3.3
4. Waste Characteristics					3.4
Chemical					
a. Toxicity/Persistence	18	1	18	18	
Hazardous Waste Quantity	8	1	8	8	
Total Waste Characteristics Score			26	26	
5. Targets					3.5
Ground Water Use	1	3	3	9	
Distance to Nearest Well/ Population Served	0	1	0	40	
Total Targets Score			3	59	
6. If line 1=45 (1x4x5) If line 1=0 (2x3x4x5)			3510	57330	
7. Line 6/57330 * 100	Sc(gw)= 6.12				

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HRS Surface Water Route Work Sheet

Site: U.S. DOE Hanford 100 Area 8/17/87

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	45	1	45	45	4.1

If observed release is given a score of 45, proceed to line 4.
If observed release is given a score of 0, proceed to line 2.

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
2. Route Characteristics					4.2
Facility Slope & Intervening Terrain	0	1	0	3	–
1-yr. 24-hr. Rainfall	0	1	0	3	
Distance to Nearest Surface Water	0	2	0	6	
Physical State	0	1	0	3	
Total Route Characteristics Score			0	15	
3. Containment	0	1	0	3	4.3
4. Waste Characteristics					4.4
a. Chemical					
Toxicity/Persistence	18	1	18	18	
Hazardous Waste Quantity	8	1	8	8	
Total Waste Characteristics Score			26	26	
5. Targets					4.5
Surface Water Use	3	3	9	9	
Distance to a Sensitive Environment	0	2	0	6	
Population Served/Distance to Water Intake Downstream	35	1	35	40	
Total Targets Score			44	55	
6. If line 1=45 (1x4x5) If line 1=0 (2x3x4x5)			51480	64350	

7. Line 6/64350 * 100 Sc(sw)= 80.00

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HRS Air Route Work Sheet

ROUTE NOT SCORED

Rating Factor	Assigned Value	Multi-plier	Score	Max. Score	Ref. (Section)
1. Observed Release	0	1	0	45	5.1
Date and Location:					
Sampling Protocol:					
If observed release is given a score of 45, proceed to line 2. If observed release is given a score of 0, the Sa=0. Enter on Line 5.					
2. Waste Characteristics					5.2
a. Chemical Reactivity and Incompatibility	0	1	0	3	
Toxicity	0	3	0	9	
Hazardous Waste Quantity	0	1	0	8	
Total Waste Characteristics Score			0	20	
3. Targets					5.3
Population Within 4-Mile Radius	0	1	0	30	
Distance to Sensitive Environment	0	2	0	6	
Land Use	0	1	0	3	
Total Targets Score			0	39	
4. Multiply 1 x 2 x 3			0	35100	

5. Line 4/35100 * 100 Sc(a)= 0.00

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	S	S^2
Groundwater Route Score (S_{gw})	6.12	37.45
Surface Water Route Score (S_{gw})	80.00	6400.00
Air Route Score (S_a)	0.00	0.00
$S_{gw}^2 + S_{sw}^2 + S_a^2$	-	6437.45
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$	-	80.23
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$ / 1.73 = S_M =	-	46.38

FIGURE 10
WORKSHEET FOR COMPUTING S_M

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DOCUMENTATION RECORDS
FOR
HAZARD RANKING SYSTEM

INSTRUMENTATIONS: As briefly as possible summarize the information you used to assign the score for each factor (e.g., "Waste quantity = 4,230 drums plus 800 cubic yards of sludge"). The source of information should be provided for each entry and should be a bibliographic-type reference, include the location of the document.

FACILITY NAME: U.S. DOE Hanford 100 Area

LOCATION: Hanford Site, Benton County, Washington

DATE SCORED: 8-17-87

PERSON SCORING: R. D. Stenner, Pacific Northwest Laboratory for DOE

PRIMARY SOURCE(S) OF INFORMATION (e.g., EPA region, state, FIT, etc.):

The information was taken from Department of Energy documents and databases associated with the Hanford Site, as well as from other publicly available documents addressing conditions at or in the vicinity of the Hanford Site. Information was also gathered through telephone and personal communications with responsible individuals (such information is referenced accordingly in the package).

FACTORS NOT SCORED DUE TO INSUFFICIENT INFORMATION:

Even though air concentrations of some of the constituents of interest can be detected above background offsite, no air monitoring data were found sufficient for HRS scoring of the Hanford CERCLA sites. These constituents of interest detected above background offsite are present in the routine gaseous effluents from operating facilities at Hanford. Therefore, the air route rating factors were not scored.

COMMENTS OR QUALIFICATIONS:

The Department of Energy has completed a preliminary assessment of the hazardous waste sites located on the Hanford Site. This work served as the primary basis for developing the scores for the aggregate 100 Area Site. These preliminary assessment efforts are documented in the "Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford" volumes and respective addenda which are referenced throughout the package.

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GROUND WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected (5 maximum):

An observed release to the ground water beneath the 100 Areas can be verified using several different substances. For the purpose of documenting observed release to the ground water it was determined that the strontium-90 (Sr-90) and chromium (Cr) would provide sufficient evidence. Evidence of observed release can be given in terms of a comparison of background concentrations and down gradient concentrations for both Sr-90 and Cr. Wells used to verify observed release of Sr-90 are listed in the following table.

100 Area Wells for Sr-90

BACKGROUND			DOWN GRADIENT		
Date	Well	Concentration (pCi/L)	Date	Well	Concentration (pCi/L)
4/10/87	1-H4-5	<0.753 pCi/L	4/10/87	1-H4-4	8.05 pCi/L
			5/29/87	1-N-4	12.5 pCi/L

The wells used to verify observed release of Cr to the ground water beneath the 100 Area are listed in the following table.

100 Area Wells for Cr

BACKGROUND			DOWN GRADIENT		
Date	Well	Concentration (μg/L)	Date	Well	Concentration (μg/L)
6/12/87	6-77-54	<10 μg/L	5/21/87	1-B3-1	62 μg/L
			3/25/87	1-D5-12	1,560 μg/L
			3/18/87	1-K-20	137 μg/L

Reference 5, page 3.14; Reference 2; Reference 3, pages 19, 23, 274, 13,16, and 21; Reference 1; Reference 10; Reference 18

Rationale for attributing the contaminants to the facility:

The nine 100 Areas (B, C, D, DR, KE, KW, F, H, and N) border the Columbia River in the northernmost part of the Hanford Site. Each of the nine areas has one production reactor. Eight of these reactors have been shut down; only the N Reactor, used for both plutonium and electricity production is still in operation. When the reactors were operational, cooling water was drawn from the river and treated with alum, sulfuric acid and chlorine. Excess sulfuric acid was used to maintain the pH of the water within a desired range. To control oxidation of aluminum parts in the reactor, sodium dichromate was used to maintain an oxidation coating on aluminum parts. The chlorine was added for algae control in the settling basins; at times copper

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sulfate was added for additional algae control. As the cooling water passed through the reactor various activation products (e.g, Co-60, Ni-63, etc.) were dissolved in the cooling water. When a fuel element ruptured or developed a pin hole in its' cladding some fission products such as Sr-90 would dissolve in the cooling water. Chromic acid, oxalic acid and nitric acid were used for dummy fuel-element decontamination. In addition to vertical safety rods for emergency reactor shutdown, the reactors were equipped with hoppers of nickel-plated boron steel balls, nickel-plated carbon steel balls, and stainless steel balls that would drop into the vertical safety rod channels for emergency shutdown. This system required no supplementary power source. Although it was never used, a third safety system, one involving the use of potassium borate solution, was in place at the reactors. A supplementary control system, in addition to the normal horizontal control rods, was incorporated into the reactors. This supplementary control system consisted of a Poison[a] Column Control Facility that could charge selected process tubes with a lead-cadmium poison to absorb neutrons. Boron-carbide aluminum poison splines were also used for supplementary control. These activities resulted in waste containing the contaminants discussed above being disposed of in the 100 Area. Down gradient wells show contaminant concentrations significantly above those found in the background wells.

(a) The term poison refers to a material's ability to absorb neutrons and thus control the rate of fission.

Reference 4, pages 2.11-2.13

2 ROUTE CHARACTERISTICS

Depth to Aquifer of Concern

Name/description of aquifer(s) of concern:

The aquifer of concern is the unconfined aquifer which is comprised of the glacio fluvial sediments of the Hanford formation and the late deposits of the Ringold formation. It generally slopes downward from west to east; depth to ground water is from 10 to 15 meters (34 to 48 feet). It is bounded below by either the basalt surface or, in places, the relatively impervious clays and silts of the lower unit of the Ringold formation. Laterally, the unconfined aquifer is bounded by the anticlinal basalt ridges that ring the basin. The Yakima and Columbia Rivers, however, do not entirely transect these sediments and therefore do not constitute a discontinuity for HRS Scoring purposes. The basalt ridges above the water table have a low permeability and act as a barrier to lateral flow of the ground water. The saturated thickness of the unconfined aquifer is greater than 61 m in some areas of the Hanford Site and pinches out along the flanks of the basalt anticlines.

Recharge to the unconfined aquifer originates from several sources. Natural recharge occurs from precipitation at higher elevations and runoff from

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9 1 1 1 8 9 1 0 0 9 5 8

ephemeral streams to the west, such as Cold Creek and Dry Creek. The Yakima River recharges the unconfined aquifer as it flows along the southwest boundary of the Hanford Site. The Columbia River recharges the unconfined aquifer during high stages when river water is transferred to the aquifer along the river bank. The unconfined aquifer receives little recharge from precipitation directly on the Hanford Site because of a high rate of evapotranspiration under native soil and vegetation conditions. Large scale artificial recharge occurs from offsite agricultural irrigation and liquid-waste disposal in the operating areas at Hanford.

Underlying the surface sands is a mixture of sand and gravel extending to a depth of about 200 feet (60 meters). Basaltic rock starts at that depth and extends downward over 1.9 miles (3000 meters).

Reference 5, page 2.5; Reference 4, pages 2.11-13; Reference 9

Depth(s) from the ground surface to the highest seasonal level of the saturated zone [water table(s)] of the aquifer of concern:

Not applicable.

Depth from the ground surface to the lowest point of waste disposal/storage:

Not applicable.

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Net Precipitation

Mean annual or seasonal precipitation (list months for seasonal):

Not applicable.

Mean annual lake or seasonal evaporation (list months for seasonal):

Not applicable.

Net precipitation (subtract the above figures):

Not applicable.

Permeability of Unsaturated Zone

Soil type in unsaturated zone:

Not applicable.

Permeability associated with soil type:

Not applicable

Physical State

Physical state of substances at time of disposal (or at present time for generated gases):

Not applicable.

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3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Not applicable.

Method with highest score:

Not applicable.

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated:

These substances are associated with production reactor operation (See Tables 1 and 2):

Substances in the 100 Area

uranium	mercury	cesium-137
lead	plutonium-238	cesium-134
cadmium	plutonium-239	europium-152
sodium dichromate	plutonium-240	europium-154
sodium oxalate	tritium	europium-155
sulfuric acid	cobalt-60	sodium sulfamate
sulfamic acid	strontium-90	nickel-63
potassium borate	copper sulfate	sodium hydroxide

Reference 4, pages 2.11-2.13; Reference 6 (The numerous individual pages are not included in the package, please consult the reference 6 document using the list of individual sites listed on the cover sheet of this package for verification of which individual sites contain which substances); Reference 19

Compound with highest score:

Several of these substances results in a score of 18. Uranium, lead, mercury sodium dichromate and plutonium are among those having scores of 18.

Substance	Toxicity Score	Persistence Score	TOTAL Score
uranium	3	3	18
lead	3	3	18
mercury	3	3	18
dichromate	3	3	18
plutonium	3	3	18

Reference 7, pages 794-797; REference 20.

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Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

The total quantity of hazardous substances associated with the aggregate 100 Area Site is estimated to be 4.3 billion cubic yards. Table 1 presents the individual sites and associated data for the 100 Area Liquid Waste Sites that were used in creating the aggregate 100 Area Site. Table 2 presents the individual sites and associated data for the 100 Area Solid Waste Sites that were used in creating the aggregate 100 Area Site.

References are listed by waste site in Table 1.

Basis of estimating and/or computing waste quantity:

The volume of wastes disposed of to waste sites at the 100 Area was calculated as the sum of the volumes received by individual waste sites. The basis for this estimate of liquid waste volume is given in Table 1. For purposes of developing the inventories, individual waste sites were aggregated into groups that received similar wastes. These groups, and the individual sites comprising each group, are identified in Table 1. Also included in this table are a description of the general types of waste received by the group of sites, the period of operation covered by the group, the estimated waste volume received by the group, and the references for the waste volumes received by the individual sites. In some cases, an individual site received more than one type of waste. If so, the site was assigned to more than one group and its waste volume was divided into the volumes received by each particular site group. Similar information for 100 Area sites receiving solid wastes is presented in Table 2.

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TABLE 1. 100 AREA LIQUID WASTE SITES

Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Decontamination Waste Cribs (116-B-4, 116-B-6, 116-C-2, 116-D-1A, 116-D-1B, 116-F-5, 116-F-10, 116-H-3, 116-K-2)	Decontamination solutions consisting of chromic, oxalic, and/or sulfuric acid solutions neutralized with soda ash. Solutions were used to decontaminate dummy fuel elements and reactor hardware.	1947-1970	2.3×10^6 L	3,000	Reference 6, pages 13-14, 17-20, 45-48, 59-60, 61-62, 113-114, 121-122, 151-152, 173-174
100 Area Contaminated Reactor Effluent Cribs and Trenches (116-B-1, 116-B-3, 116-C-1, 116-D-2, 116-DR-1, 116-DR-2, 116-DR-4, 116-F-1, 116-F-2, 116-F-3, 116-F-4, 116-H-1, 116-H-4, 116-K-1, 116-K-2)	Reactor effluent contaminated when fuel element cladding failed. Radiological contamination consisted chiefly of mixed fission products. Chemical contamination consisted of sodium dichromate added to reactor coolant as oxidant.	1946-1971	3.0×10^{11} L	3.9×10^8	Reference 6, pages 7-8, 11-12, 43-44, 63-64, 87-88, 89-90, 93-94, 105-106, 107-108, 109-110, 111-112, 147-148, 153-154, 171-172, 173-174

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Laboratory Waste Cribs and Trenches (116-B-5, 116-B-10, 116-C-2, 116-D-3, 116-D-4, 116-F-9, 116-F-13)	Wastes associated with labs and shops in the 108 Buildings, including 108-B Tritium Lab and Tube Examination Facility, 108-C Metal Examination Facility and 100 F Biology Labs. Contaminants consisted mainly of tritium and low levels of mixed fission and activation products. Negligible chemical contamination except Biology Lab facilities, which received nitrate from animal wastes.	1950-1976	3.2×10^8 L	4.2×10^5	Reference 6, pages 15-16, 23-24, 45-48, 65-66, 67-68, 119-120, 127-128
100 Area Fuel Storage Basin Cribs and Trenches (116-B-2, 116-D-1A, 116-D-1B, 116-DR-3, 116-F-3, 116-KE-3, 116-KW-2)	Storage basin cooling water contaminated with low levels of mixed fission products due to failure of fuel element cladding.	1946-1971	2.0×10^7 L	2.6×10^4	Reference 6, pages 9-10, 59-60, 61-62, 91-92, 109-110, 179-180, 195-196

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Reactor Decontamination and Maintenance Effluents Cribs and Trenches (116-DR-6, 116-F-1, 116-F-6, 116-F-12, 116-H-2, 116-K-2)	Reactor effluents during reactor maintenance activities. Much of the waste volume was uncontaminated. Radionuclides present were mainly low levels of mixed fission products and activation products. The main chemical contaminant was sulfuric acid, which was used for reactor decontamination. Sodium dichromate was also present in some of the effluents.	1945-1971	6.1×10^8 L	8.0×10^5	Reference 6, pages 95-96, 105-106, 115-116, 125-126, 149-150, 173-174
100 Area Reactor Confinement Seal Pit Drainage Cribs (116-DR-8, 116-F-7, 117-B, 117-C, 117-D, 117-H)	Drainage from 117 Building confinement system seal pits. Very low levels of contamination.	1960-1969	2.2×10^6 L	2,900	Reference 6, pages 42-44, 49-50, 85-86, 99-100, 117-118, 167-168
100 Area Sulfuric Acid Sludge Disposal Sites (100KE*1, 100KE*2, 100KE*3, 100KW*1, 100KW*2)	Mercury-contaminated sludge from sulfuric acid storage tanks.	1955-1971	3.7×10^4 L	48	Reference 6, pages 181-183, 185-187, 189-191, 197-199, 201-203

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Miscellaneous Floor and Sink Drain Cribs (116-B-9, 116-D-6, 116-F-11)	Drainage from floor and sink drains. Very low levels of radioactive contamination. No chemical contamination.	1952-1967	3.4×10^5 L	440	Reference 6, pages 21-22, 69-70, 123-124
100 Area Potassium Borate Crib (116-DR-7)	Liquid potassium borate solution. No radioactive contamination.	1953	4×10^3 L	5.2	Reference 6, pages 97-98
100 Area Gas Purification Condensate Cribs (116-KE-1, 116-KW-1)	Condensate from reactor gas purification system. Contaminated with tritium and carbon-14 and small amounts of fission products.	1955-1971	1.6×10^6 L	2.1×10^3	Reference 6, pages 175-176, 193-194
100 Area Ion Exchange Regenerant Crib (116-KE-2)	Wastes from regeneration of ion exchange columns. Contained sulfuric acid, caustic, and mixed fission products and activation products.	1955-1971	3.0×10^6 L	3.9×10^3	Reference 6, pages 177-178

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Retention Basin Leakage (107-B, 107-C, 107-D, 107-DR, 107-F, 107-H, 107-KE, 107-KW)	Reactor effluent containing very small amounts of fission products and activation products. Chemical contamination limited to small amounts of sodium dichromate added to reactor coolant as oxidant.	1944-1971	3.0×10^{12} L	3.9×10^{9}	Reference 16
100 Area White Bluffs Pickling Acid Crib	Waste nitric and hydrofluoric acid used to pickle galvanized piping. Acid may or may not have been neutralized.	1943-1945	7×10^{5} L	900	Reference 16
		TOTAL	3.3×10^{12} L	4.3×10^{9}	

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TABLE 2. 100 AREA SOLID WASTE SITES

Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Metallic Waste Burial Grounds (118-B-1, 118-B-4, 118-B-5, 118-C-2, 118-D-1, 118-D-3, 118-D-5, 118-DR-1, 118-F-1, 118-F-3, 118-F-7, 118-H-1, 118-H-2, 118-H-3, 118-H-4, 118-H-5, 118-K)	Metallic waste consisting mainly of discarded reactor hardware, including such items as aluminum tubes and spacers; lead and cadmium containing slugs, graphite, desiccant, aluminum and boron splines; lead; and mercury. Radioactive contaminants, primarily activation products.	1944-1975	1,000 m^3	1,300	Reference 6, pages 25-27, 33-34, 35-36, 55-56, 71-72, 77-79, 83-84, 101-102, 129-131, 135-136, 143-144, 155-157, 159-160, 161-162, 163-164, 165-166, 205-207
100 Area Construction Waste Burial Grounds (118-B-2, 118-B-3, 118-D-4, 118-F-1, 118-H-3)	Construction waste, demolition debris. Small amounts of radioactive contamination.	1953-1967	48,000 m^3	63,000	Reference 6, pages 29-30, 31-32, 81-82, 129-131, 161-162
100 Area Lab Waste Burial Grounds (118-B-6, 118-F-5, 118-F-6)	Low-level radioactive wastes from 100 Area laboratories, including tritium wastes and animal wastes.	1950-1975	20,000 m^3	26,000	Reference 6, pages 37-38, 139-140, 141-142

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Miscellaneous Solid Waste Burial Grounds (118-B-1, 118-B-7, 118-C-1, 118-D-1, 118-D-2, 118-F-2, 118-F-4, 118-H-1, 118-K)	Radioactivity contaminated trash and miscellaneous solid wastes from 100 Area facilities.	1944-1975	61,000 m^3	80,000	Reference 6, pages 25-27, 39-40, 51-53, 71-72, 73-75, 133-134, 137-138, 155-157, 205-207
100 Area Burn Pits (100 B/C Burn Pit, 100/DR Burn Pit, 100F Burn Pit, 100N Burn Pit, 100K Burn Pit)	Combustible trash from 100 Area buildings and offices.	1943-1971	130,000 m^3	170,000	Reference 6, pages 57-58, 103-104, 145-146, 169-170, 209-210
		TOTAL	260,000 m^3	340,000 yd^3	

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5 TARGETS

Ground Water Use

Use(s) of aquifer(s) of concern within a 3-mile radius of the facility:

There are no wells which draw water for drinking or irrigation purposes within 3 miles of the 100 Area. Therefore, there is no use of the aquifer of concern within 3 miles of the 100 Area.

Reference 8

Distance to Nearest Well

Location of nearest well drawing from aquifer of concern or occupied building not served by a public water supply:

The nearest wells are 699-72-101A, B, and C that are located at the Vernita Bridge Rest Stop.

Reference 8; Reference 9, page II.1-65

Distance to above well or building:

The wells located at the Vernita Bridge Rest Stop are just over 3 miles from the boundary of the 300 Area Site.

Reference 8

Population Served by Ground Water Wells Within a 3-Mile Radius

Identified water-supply well(s) drawing from aquifer(s) of concern within a 3-mile radius and populations served by each:

There are no wells which draw water for drinking or irrigation purposes within 3 miles of the 100 Area. Therefore, there is no use of the aquifer of concern within 3 miles of the 100 Area.

Reference 8

Computation of land areas irrigated by supply well(s) drawing from aquifer(s) of concern within a 3-mile radius, and conversion to population (1.5 people per acre):

There are no documented irrigation wells within 3 miles of the site.

Total population served by ground water within a 3-mile radius:

The total population served by ground water within 3 miles is zero.

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[illegible]

SURFACE WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected in surface water at the facility or downhill from it (5 maximum):

The observed release of contaminants to the Columbia River adjacent to the 100 Area can be verified by comparison of upstream and downstream concentrations of selected constituents. Verification of observed release does not require evidence of release for each contaminant disposed at the facility, but relies on identification of at least one constituent in the surface water that can be attributed to the facility. Strontium-90 (Sr-90) was chosen to illustrate observed release from the 100 Area. The following table compares upstream concentrations of Sr-90 with concentrations of Sr-90 at designated surface water use points. The water intakes designated as use points are in the 100N and 100D areas.

BACKGROUND			DOWN GRADIENT[a]		
Date	Sample Point	Concentration (pCi/L)	Date	Sample Point	Concentration (pCi/L)
11/23/82-12/21/82	Prst Rap	0.34 ± 0.18	12/18/82	100N	28 ± 0.47
			12/18/82	100D	1.1 ± 0.05

(a) This data represents an analysis of the composite of river water samples taken every 0.5 mile for the river interval indicated on the date shown.

Reference 11; Reference 5, page 3.14; Reference 12, pages 15 and B.3; Reference 10

Rationale for attributing the contaminants to the facility:

The nine 100 Areas (B, C, D, DR, KE, KW, F, H, and N) border the Columbia River in the northernmost part of the Hanford Site. Each of the nine areas has one production reactor. Eight of these reactors have been shut down; only the N Reactor, used for both plutonium and electricity production is still in operation. When the reactors were operational, cooling water was drawn from the river and treated with alum, sulfuric acid and chlorine. Excess sulfuric acid was used to maintain the pH of the water within a desired range. To control oxidation of aluminum parts in the reactor, sodium dichromate was used to maintain an oxidation coating on aluminum parts. The chlorine was added for algae control in the settling basins; at times copper sulfate was added for additional algae control. As the cooling water passed through the reactor various activation products (e.g, Co-60, Ni-63, etc.) were dissolved in the cooling water. When a fuel element ruptured or developed a pin hole in its' cladding some fission products such as Sr-90 would dissolve in the cooling water. Chromic acid, oxalic acid and nitric

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acid were used for dummy fuel-element decontamination. In addition to vertical safety rods for emergency reactor shutdown, the reactors were equipped with hoppers of nickel-plated boron steel balls, nickel-plated carbon steel balls, and stainless steel balls that would drop into the vertical safety rod channels for emergency shutdown. This system required no supplementary power source. Although it was never used, a third safety system, one involving the use of potassium borate solution, was in place at the reactors. A supplementary control system, in addition to the normal horizontal control rods, was incorporated into the reactors. This supplementary control system consisted of a Poison[a] Column Control Facility that could charge selected process tubes with a lead-cadmium poison to absorb neutrons. Boron-carbide aluminum poison splines were also used for supplementary control.

These activities resulted in strontium-90 contaminated waste being disposed of in the 100 Area, and down gradient samples show strontium-90 concentration levels significantly above the strontium-90 concentrations found in background samples.

(a) The term poison refers to a material's ability to absorb neutrons and thus control the rate of fission.

Reference 4, pages 2.11-2.13

2 ROUTE CHARACTERISTICS

Facility Slope and Intervening Terrain

Average slope of facility in percent:

Not applicable.

Name/description of nearest down slope surface water:

The Columbia River, which originates in the mountains of eastern British Columbia, Canada, flows through the northern edge of the Hanford Site and forms part of the Hanford Site's eastern boundary. The river drains a total area of approximately 70.800 km^2 enroute to the Pacific Ocean. The flow of the Columbia River is regulated by 11 dams within the United States, 7 upstream and 4 downstream of the Site. Priest Rapids Dam is the nearest impoundment upstream of the Site, and McNary Dam is the nearest dam downstream. (The Hanford reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula, which is created by McNary Dam.) This is the only stretch of the Columbia River within the U.S. that is not impounded by a dam. The width of the river varies from approximately 300 m to about 1000 m. The flow through this stretch of the river is relatively swift, with numerous bends and several islands present throughout the reach. The ground water beneath the site discharges directly into the Columbia River as evidenced by seeps and springs along the river shore.

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The flow rate of the Columbia River in this region is regulated primarily by Priest Rapids Dam. Hanford reach flows fluctuate significantly because of the relatively small storage capacity and operational practices of the nearby upstream dams. A minimum flow rate of 1,000 cubic meters per second (36,000 cubic feet per second) has been established at Priest Rapids. Typical daily flows range from 1,000 cubic meters per second (36,000 cubic feet per second) to 7,000 cubic meters per second (250,000 cubic feet per second) with peak spring runoff flows of up to 12,600 cubic meters per second (450,000 cubic feet per second) being recorded. Typical annual average flows at Priest Rapids Dam are 3,100 cubic meters per second (110,000 cubic feet per second) to 3,400 cubic meters per second (120,000 cubic feet per second). Monthly mean flows typically peak from April through June and are at the lowest levels from September through October.

Reference 5, page 2.1-2.3

Average slope of terrain between facility and above-cited surface water body in percent:

Not applicable.

Is the facility located either totally or partially in surface water?

Not applicable.

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Is the facility completely surrounded by areas of higher elevation?

Not applicable.

1-Year 24-Hour Rainfall in Inches

Not applicable.

Distance to Nearest Down slope Surface Water

Not applicable.

Physical State of Waste

Not applicable.

3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Not applicable.

Method with highest score:

Not applicable.

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4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated

These substances are associated with production reactor operation (See Tables 1 and 2):

Substances in the 100 Area

uranium	mercury	cesium-137
lead	plutonium-238	cesium-134
cadmium	plutonium-239	europium-152
sodium dichromate	plutonium-240	europium-154
sodium oxalate	tritium	europium-155
sulfuric acid	cobalt-60	sodium sulfamate
sulfamic acid	strontium-90	nickel-63
potassium borate	copper sulfate	sodium hydroxide

Reference 4, pages 2.11-2.13; Reference 6 (The numerous individual pages are not included in the package, please consult the reference 6 document using the list of individual sites listed on the cover sheet of this package for verification of which individual sites contain which substances); Reference 19

Compound with highest score:

Several of these substances results in a score of 18. Uranium, lead, mercury sodium dichromate and plutonium are among those having scores of 18.

Substance	Toxicity Score	Persistence Score	TOTAL Score
uranium	3	3	18
lead	3	3	18
mercury	3	3	18
dichromate	3	3	18
plutonium	3	3	18

Reference 7, pages 794-797; Reference 20.

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

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The total quantity of hazardous substances associated with the aggregate 100

Area Site is estimated to be 4.3 billion cubic yards. Table 1 presents the individual sites and associated data for the 100 Area Liquid Waste Sites that were used in creating the aggregate 100 Area Site. Table 2 presents the individual sites and associated data for the 100 Area Solid Waste Sites that were used in creating the aggregate 100 Area Site.

References are listed by waste site in Table 1.

Basis of estimating and/or computing waste quantity:

The volume of wastes disposed of to waste sites at the 100 Area was calculated as the sum of the volumes received by individual waste sites. The basis for this estimate of liquid waste volume is given in Table 1. For purposes of developing the inventories, individual waste sites were aggregated into groups that received similar wastes. These groups, and the individual sites comprising each group, are identified in Table 1. Also included in this table are a description of the general types of waste received by the group of sites, the period of operation covered by the group, the estimated waste volume received by the group, and the references for the waste volumes received by the individual sites. In some cases, an individual site received more than one type of waste. If so, the site was assigned to more than one group and its waste volume was divided into the volumes received by each particular site group. Similar information for 100 Area sites receiving solid wastes is presented in Table 2.

In compiling the inventory, since groundwater seeps into the Columbia River, it is assumed that the containment associated with the surface water route is considered not to be 0, and all the waste quantities cited were available for migration.

Reference 12; Reference 19.

5 TARGETS

Surface Water Use

Use(s) of surface water within 3 miles downstream of the hazardous substance:

The Columbia River is used as the source of drinking and process water for the 100 and 200 areas. The intake at 100-B Pumphouse supplies water to 100-B/C, 100-D, 100-N, 100-K, and the 200 areas. The intake at 100-D is used as a backup to 100-B intake. The 100-N intake supplies water to 100-N area and Washington Public Power Supply System Generation Station attached to the 100-N reactor. The 100-K Pumphouse supplies water to 100-K area.

The Columbia River both near and down stream of the 100 Area is used for recreation.

Reference 9, pages II.1-64-II.1-65; Reference 13, page 3; Reference 17. 1/11/88 KEA

TABLE 1. 100 AREA LIQUID WASTE SITES

Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Decontamination Waste Cribs (116-B-4, 116-B-6, 116-C-2, 116-D-1A, 116-D-1B, 116-F-5, 116-F-10, 116-H-3, 116-K-2)	Decontamination solutions consisting of chromic, oxalic, and/or sulfuric acid solutions neutralized with soda ash. Solutions were used to decontaminate dummy fuel elements and reactor hardware.	1947-1970	2.3×10^6 L	3,000	Reference 6, pages 13-14, 17-20, 45-48, 59-60, 61-62, 113-114, 121-122, 151-152, 173-174
100 Area Contaminated Reactor Effluent Cribs and Trenches (116-B-1, 116-B-3, 116-C-1, 116-D-2, 116-DR-1, 116-DR-2, 116-DR-4, 116-F-1, 116-F-2, 116-F-3, 116-F-4, 116-H-1, 116-H-4, 116-K-1, 116-K-2)	Reactor effluent contaminated when fuel element cladding failed. Radiological contamination consisted chiefly of mixed fission products. Chemical contamination consisted of sodium dichromate added to reactor coolant as oxidant.	1946-1971	3.0×10^{11} L	3.9×10^8	Reference 6, pages 7-8, 11-12, 43-44, 63-64, 87-88, 89-90, 93-94, 105-106, 107-108, 109-110, 111-112, 147-148, 153-154, 171-172, 173-174

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Laboratory Waste Cribs and Trenches (116-B-5, 116-B-10, 116-C-2, 116-D-3, 116-D-4, 116-F-9, 116-F-13)	Wastes associated with labs and shops in the 108 Buildings, including 108-B Tritium Lab and Tube Examination Facility, 108-C Metal Examination Facility and 100 F Biology Labs. Contaminants consisted mainly of tritium and low levels of mixed fission and activation products. Negligible chemical contamination except Biology Lab facilities, which received nitrate from animal wastes.	1950-1976	3.2×10^8 L	4.2×10^5	Reference 6, pages 15-16, 23-24, 45-48, 65-66, 67-68, 119-120, 127-128
100 Area Fuel Storage Basin Cribs and Trenches (116-B-2, 116-D-1A, 116-D-1B, 116-DR-3, 116-F-3, 116-KE-3, 116-KW-2)	Storage basin cooling water contaminated with low levels of mixed fission products due to failure of fuel element cladding.	1946-1971	2.0×10^7 L	2.6×10^4	Reference 6, pages 9-10, 59-60, 61-62, 91-92, 109-110, 179-180, 195-196

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Reactor Decontamination and Maintenance Effluents Cribs and Trenches (116-DR-6, 116-F-1, 116-F-6, 116-F-12, 116-H-2, 116-K-2)	Reactor effluents during reactor maintenance activities. Much of the waste volume was uncontaminated. Radionuclides present were mainly low levels of mixed fission products and activation products. The main chemical contaminant was sulfuric acid, which was used for reactor decontamination. Sodium dichromate was also present in some of the effluents.	1945-1971	6.1×10^{8} L	8.0×10^{5}	Reference 6, pages 95-96, 105-106, 115-116, 125-126, 149-150, 173-174
100 Area Reactor Confinement Seal Pit Drainage Cribs (116-DR-8, 116-F-7, 117-B, 117-C, 117-D, 117-H)	Drainage from 117 Building confinement system seal pits. Very low levels of contamination.	1960-1969	2.2×10^{6} L	2,900	Reference 6, pages 42-44, 49-50, 85-86, 99-100, 117-118, 167-168
100 Area Sulfuric Acid Sludge Disposal Sites (100KE*1, 100KE*2, 100KE*3, 100KW*1, 100KW*2)	Mercury-contaminated sludge from sulfuric acid storage tanks.	1955-1971	3.7×10^{4} L	48	Reference 6, pages 181-183, 185-187, 189-191, 197-199, 201-203

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Miscellaneous Floor and Sink Drain Cribs (116-B-9, 116-D-6, 116-F-11)	Drainage from floor and sink drains. Very low levels of radioactive contamination. No chemical contamination.	1952-1967	3.4×10^5 L	440	Reference 6, pages 21-22, 69-70, 123-124
100 Area Potassium Borate Crib (116-DR-7)	Liquid potassium borate solution. No radioactive contamination.	1953	4×10^3 L	5.2	Reference 6, pages 97-98
100 Area Gas Purification Condensate Cribs (116-KE-1, 116-KW-1)	Condensate from reactor gas purification system. Contaminated with tritium and carbon-14 and small amounts of fission products.	1955-1971	1.6×10^6 L	2.1×10^3	Reference 6, pages 175-176, 193-194
100 Area Ion Exchange Regenerant Crib (116-KE-2)	Wastes from regeneration of ion exchange columns. Contained sulfuric acid, caustic, and mixed fission products and activation products.	1955-1971	3.0×10^6 L	3.9×10^3	Reference 6, pages 177-178

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Retention Basin Leakage (107-B, 107-C, 107-D, 107-DR, 107-F, 107-H, 107-KE, 107-KW)	Reactor effluent containing very small amounts of fission products and activation products. Chemical contamination limited to small amounts of sodium dichromate added to reactor coolant as oxidant.	1944-1971	3.0×10^{12} L	3.9×10^{9}	Reference 16
100 Area White Bluffs Pickling Acid Crib	Waste nitric and hydrofluoric acid used to pickle galvanized piping. Acid may or may not have been neutralized.	1943-1945	7×10^{5} L	900	Reference 16
		TOTAL	3.3×10^{12} L	4.3×10^{9}	

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TABLE 2. 100 AREA SOLID WASTE SITES

Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Metallic Waste Burial Grounds (118-B-1, 118-B-4, 118-B-5, 118-C-2, 118-D-1, 118-D-3, 118-D-5, 118-DR-1, 118-F-1, 118-F-3, 118-F-7, 118-H-1, 118-H-2, 118-H-3, 118-H-4, 118-H-5, 118-K)	Metallic waste consisting mainly of discarded reactor hardware, including such items as aluminum tubes and spacers; lead and cadmium containing slugs, graphite, desiccant, aluminum and boron splines; lead; and mercury. Radioactive contaminants, primarily activation products.	1944-1975	1,000 m^3	1,300	Reference 6, pages 25-27, 33-34, 35-36, 55-56, 71-72, 77-79, 83-84, 101-102, 129-131, 135-136, 143-144, 155-157, 159-160, 161-162, 163-164, 165-166, 205-207
100 Area Construction Waste Burial Grounds (118-B-2, 118-B-3, 118-D-4, 118-F-1, 118-H-3)	Construction waste, demolition debris. Small amounts of radioactive contamination.	1953-1967	48,000 m^3	63,000	Reference 6, pages 29-30, 31-32, 81-82, 129-131, 161-162
100 Area Lab Waste Burial Grounds (118-B-6, 118-F-5, 118-F-6)	Low-level radioactive wastes from 100 Area laboratories, including tritium wastes and animal wastes.	1950-1975	20,000 m^3	26,000	Reference 6, pages 37-38, 139-140, 141-142

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Area No. and Name	Waste Types	Years	Estimated Volume	No. of Cubic Yds	References
100 Area Miscellaneous Solid Waste Burial Grounds (118-B-1, 118-B-7, 118-C-1, 118-D-1, 118-D-2, 118-F-2, 118-F-4, 118-H-1, 118-K)	Radioactivity contaminated trash and miscellaneous solid wastes from 100 Area facilities.	1944-1975	61,000 m^3	80,000	Reference 6, pages 25-27, 39-40, 51-53, 71-72, 73-75, 133-134, 137-138, 155-157, 205-207
100 Area Burn Pits (100 B/C Burn Pit, 100/DR Burn Pit, 100F Burn Pit, 100N Burn Pit, 100K Burn Pit)	Combustible trash from 100 Area buildings and offices.	1943-1971	130,000 m^3	170,000	Reference 6, pages 57-58, 103-104, 145-146, 169-170, 209-210
		TOTAL	260,000 m^3	340,000 yd^3	

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Is there tidal influence?

The site is located upstream of four dams, therefore, there is not tidal influence at the site.

Reference 5, page 2.1

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Not applicable.

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

No fresh-water wetlands were found near the Hanford Site.

Reference 8

Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:

Although there are several sensitive and threatened species that are residents of Hanford Site (for at least part of the year), no endangered species are known to be residents of the site. Two threatened species, the bald eagle and the ferruginous hawk, are residents of the site (for at least part of the year). Because there are no endangered species (federal listing) that reside at the site, there is no critical habitat to be considered in the ranking of the 300 Area Site.

The Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Volume 1, July 1986 listed the Merriam's Shrew as being on the State Endangered Species List. This information was taken from a list published in a preliminary draft of an environmental impact statement, and, since the referenced February 1987 list shows the Merriam's Shrew as only a proposed sensitive species, it is assumed that the previous list taken from the preliminary draft is in error.

Reference 4; Reference 14

Population Served by Surface Water

Location(s) of water-supply intake(s) within 3 miles (free-flowing bodies) or 1 mile (static water bodies) downstream of the hazardous substance and population served by each intake:

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The 100-B Pumphouse (at 100-B/C Area) supplies water to 100-B/C, 100-D, 100-N, 100-K and 200 areas. The 100-D Pumphouse (at 100 D/DR Area) is a backup to the 100-B Pumphouse. The water plant at 100-N supplies water to both 100-N and the Washington Public Power Supply System Generating Station which is attached to the 100-N reactor. The 100-K Pumphouse supplies water to the 100-K area. The worker population of the 100 Area is 760 and the population of the 200 Area is 2,355.

Reference 9, pages II.1-64-II.1-65; Reference 13, page 3; Reference 15, page 1; Reference 4; Reference 8

Computation of land area irrigated by above-cited intake(s) and conversion to population (1.5 people per acre):

There are no crops irrigated by the 100 Area intakes, and there are no documented irrigation intakes drawing from the columbia river within 3 miles of the 100 Area Site.

Total population served:

The total population served is calculated by summing all the respective population estimates:

760 + 2,355 = 3115

Name/description of nearest of the above water intakes:

The intake at the 100-D Area is the 181-D Pumphouse. The intake at the 100-N Area is the 181-N Pumphouse.

Reference 4; Reference 8

Distance to above-cited intakes, measured in stream miles.

The distance to the above intakes is zero because the intakes have documented observed releases.

Reference 4; Reference 8; Reference 11; Reference 12

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AIR ROUTE

1 OBSERVED RELEASE

Contaminants detected:

Even though air concentrations of some of the constituents of interest can be detected above background offsite, no air monitoring data were found sufficient for HRS scoring of the Hanford CERCLA sites. These constituents of interest detected above background offsite are present in the routine gaseous effluents from operating facilities at Hanford. Therefore, the air route rating factors were not scored.

Date and location of detection of contaminants:

Not Applicable

Methods used to detect the contaminants:

Not Applicable

Rationale for attributing the contaminants to the site:

Not Applicable

2 WASTE CHARACTERISTICS

<u>Reactivity and Incompatibility</u>

Most reactive compound:

Not Applicable

Most incompatible pair of compounds:

Not Applicable

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Toxicity

Most toxic compound:

Not Applicable

Hazardous Waste Quantity

Total quantity of hazardous waste:

Not Applicable

Basis of estimating and/or computing waste quantity:

Not Applicable

3 TARGETS

Population Within 4-Mile Radius

Circle radius used, give population, and indicate how determined:

0 to 4 mi   0 to 1 mi   0 to 1/2 mi   0 to 1/4 mi

Not applicable

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Not applicable

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

Not Applicable

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Distance to critical habitat of an endangered species, if 1 mile or less:

Not Applicable

Land Use

Distance to commercial/industrial area, if 1 mile or less:

Not Applicable

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

Not Applicable

Distance to residential area, if 2 miles or less:

Not Applicable

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Not Applicable

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Not Applicable

Is a historic or landmark site (National Register or Historic Places and National Natural Landmarks) within the view of the site?

Not Applicable

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HRS DOCUMENTATION LOG SHEET	SITE NAME U.S. DOE Hanford - 100 Area CITY Benton County STATE WA IDENTIFICATION NUMBER
REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
1	Strontium Determination ALL Matrices, UST-RD-PM-9-80
2	Computer Printouts from Hanford Ground Water Data Base
3	Hanford Wells, PNL-5397, February 1985
4	Draft Phase I Installation Assessment of Inactive Waste-
	Disposal Sites at Hanford, Volume 1, July 1986
5	Environmental Monitoring at Hanford for 1986, PNL-6120,
	May 1987
6	Draft Phase I Installation Assessment of Inactive Waste-
	Disposal Site at Hanford, Volume 2, July 1986
7	Uncontrolled Hazardous Waste Site Ranking System; A Users
	Manual, 40 CFR 300, Appendix A
8	U.S.G.S. Maps of the Area Around 100 Area
9	Waste Management Operations, Volume 1, ERDA-1538
10	Inductively Coupled Plasma Method, Method 6010
11	Hanford Stream data base printout showing Priest Rapids Dam
12	Investigation of Ground-Water Seepage from Hanford Shoreline
	of the Columbia River, PNL-5289, November 1984
13	Hanford Reservation Area Worker Census, BNWL-2298, July 1977
14	Endangered and Threatened Wildlife and Plants, 50 CFR,
	Part 17, Subpart B, October 86

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HRS DOCUMENTATION LOG SHEET	SITE NAME U.S. DOE Hanford - 100 Area CITY Benton County STATE WA IDENTIFICATION NUMBER
REFERENCE NUMBER	DESCRIPTION OF THE REFERENCE
15	Hanford Environmental Health Foundation Drinking Water
	Report, HEHF-45
16	Draft Phase I Installation Assessment of Inactive Waste-
	Disposal Sites at Hanford, Volume 3
17	Memo to file regarding recreational use of the Columbia River
	from DR Sherwood, August 26, 1987
18	Letter from RD Stenner to DM Bennett regarding Ground Water
	Contaminant Plume, October 14, 1987
19	Letter from RD Stenner to DM Bennett regarding Liquid Waste
	Sites and Burning Pits, October 26, 1987
20	Memo to Sandy Crystall, EPA, from Kathleen Galloway,
	MITRE. December 29, 1987.
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REFERENCE 1

<u>Strontium Determination ALL Matrices</u>, UST-RD-PM-9-80

STRONTIUM DETERMINATION
ALL MATRICES

Principle

Strontium is precipitated sequentially first as the nitrate, and then as the carbonate. The fuming nitric acid separation removes most of the other interfering ions and concentrated nitric precipitations remove calcium. Radioisotopes of barium, radium, and lead are co-precipitated with barium chromate. Iron and final traces of fission products are removed by a hydroxide scavenge using mixed hold back carrier. An additional barium and hydroxide scavenge is done on difficult matrices. Following a final carbonate precipitation, gravimetric yield and Strontium-89 plus Strontium-90 activity is determined or just Sr-85 tracer yield is established. Yttrium-90 is permitted to grow into equilibrium with the strontium-90, then separated from the strontium by successive hydroxide and oxalate precipitations. The yttrium oxalate is transferred to a counting dish, dried under a heat lamp, ignited to Yttrium Oxide, weighed for chemical recovery, and counted on a low background Beta Proportional Counter. Decay counts are made to check the purity of the Yttrium-90.

Scope: Procedures are described for the following matrices: milk, water, urine, feces, filter, soil, vegetation, and ion exchange resin. Food, bone, tissue and grains are treated as vegetation.

The different sample matrices analyzed as described in the scope require slightly different preparations. Refer to the Appropiate Preparation Procedure; 30-19-01, for Bioassay Samples and 30-20-01 for Environmental Matrices.

For Strontium analysis, varying sample types require even preliminary separations to bring them to a common point for the Strontium Determination steps summarized below.

Milk

Strontium is separated from milk and concentrated by equilibration with cation exchange resin using a batch technique. The resin after equilibration is washed with water to remove milk solids. Strontium is desorbed from the resin by equilibrating with 4M NaCl solution. Strontium is separated from the NaCl solution by precipitating as the carbonate.

Soil

Following leaching the sample is dissolved in 9M HCl and the majority of iron is removed using an isopropyl ether extraction. The HCl solution is converted back to the nitric form and a fuming nitric acid precipitation is performed. The nitric acid supernate is reserved for actinide (usually plutonium) chemistry.

Vegetation

In the case of vegetation (especially alfalfa) and produce, the sample residue may contain some radioactivity, depending on the sulfate content of the sample. Hence, following sample preparation and a fuming nitric acid precipation, the residue is dissolved in water and any insoluble material is boiled with a concentrated solution of Na_2CO_3 to convert the insoluble sulfate residue to the acid soluble carbonate (metathesis). The carbonate is then refluxed with nitric acid and combined with the soluble water fraction.

Water

For large volume sample, the sample is acidified and concentrated by evaporation, neutralized with ammonium hydroxide, and strontium then is precipitated as the carbonate. Strontium is precipitated directly from small volume samples, one liter or less, by neutralizing with ammonium hydroxide to the red end point of phenolphthalein and then adding about 25 mL saturated Na_2CO_3.

Urine and Feces

Following ashing, the sample salts are dissolved in nitric acid (aliquot of a Fecal sample is analyzed), then made basic with hydroxide and carbonate heated and precipitated as the carbonate.

Ion Exchange Resin Samples

The resin is transferred to a beaker and dried and muffled for up to 1 week or more. Sodium carbonate (Na_2CO_3) is added and a fusion is performed. The fusion "cake" is dissolved in water and a small amount of hydrochloric acid and then reprecipitated as the carbonate.

Sequential Analyses

All samples requiring other analysis (usually plutonium analysis) in addition to strontium must first have a fuming nitric separation is performed on the sample residue instead of a carbonate.

Literature References

Sunderman, D. N. and Townley, C. W., The Radiochemistry of Barium, Calcium, and Strontium. Subcommittee on Radiochemistry, National Academy of Science - National Research Council, Office of Technical Services, Department of Commerce, Washington, D.C.

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Krieger, H. L. and E. L. Whittaker, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA-600/4-80-032 August 1980.

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Urine and Feces Sample Preparation Procedure, 30-BA-SP.

Sample Preparation Procedure For Environmental Matrices, 30-ENV-SP.

Stevenson, P. C. and Nervik, W. E., The Radiochemistry of the Rare Earths: Scandium, Yttrium, and Actinium. Subcommittee on Radiochemistry, National Academy of Science - National Research Council, Office of Technical Services, Department of Commerce, Washington, D.C.

Harley, J. P., Editor. Manual of Standard Procedures. Health and Safety Laboratory, United States Atomic Energy Commission, New York, 1976.

Reagents: All chemicals are of "reagent grade" and deionized water is used throughout this procedure.

Sr carrier: 59.4 mg Sr/mL, 143.5 g $Sr(NO_3)_2$ dissolved and diluted to 1 liter with 2M HNO_3. Calibrated to 100.0 mg $SrCO_3$ per mL.

Y carrier: 20 mg Y per mL, 25.4 g Y_2O_3 dissolved in 125 mL conc. HNO_3 and diluted to 1 liter with D.I. H_2O. Calibrated to 25.4 mg Y_2O_3 per mL.

Ba carrier: 10 mg Ba^{+2}/mL, 20 g $Ba(NO_3)$ dissolved and diluted to 1 liter with D.I. water.

HNO_3: (nitric acid).
Fuming; 90% (or 24M HNO_3)
Concentrated; 16M HNO_3.
2M HNO_3; 125 mL of concentrated HNO_3 diluted to 1 liter with D.I. water.

HCl: (hydrochloric acid) concentrated or 12M HCl.
9M HCl; 750 mL of concentrated HCl diluted to 1 liter with D.I. water.
6M HCl; 500 mL of concentrated HCl diluted to 1 liter with D.I. water.

CH_3COOH: (glacial acetic), 17.4M.
1.5M acetic acid, 86 mL glacial acetic acid diluted to 1 liter with D.I. water.

$NH_4C_2H_3O_2$: (ammonium acetate) 3M.
231 g of $NH_4C_2H_3O_2$ dissolved and diluted to 1 liter with D.I. water.

Na_2CrO_4: (sodium chromate) 1.5M.
125 g Na_2CrO_4 dissolved and diluted to 1 liter with D.I. water.

NH_4OH: (ammonium hydroxide) 14.7M or concentrated.

Na_2CO_3: (sodium carbonate) saturated aqueous - 225 g Na_2CO_3 diluted to 1 liter with D.I. water.

NaOH: (sodium hydroxide) 12M or concentrated. 540 g of sodium hydroxide dissolved and diluted to 1 liter with D.I. water.
6M NaOH; 270 g of sodium hydroxide diluted to 1 liter with D.I. water.

$H_2C_2O_4 \cdot 2H_2O$: (oxalic acid) 15% solution, 150 g of $H_2C_2O_4$ dissolved and diluted to 1 liter with D.I. water.

Collodion: 10% solution, (50 mL of collodion, 300 mL of diethyl ether, 150 mL of ethyl alcohol)

Methyl red indicator, 0.1%: Dissolve 0.1 g methyl red in 100 mL D.I. water.

Phenylphthalein indicator, 0.1%: 1 g phenylphthalein dissolved in 700 mL of 95% ethanol and 300 mL D.I. water.

Mixed Co, Ce, Cs, Mn, Ni, Fe Hold Back Carrier:

This solution when prepared as below will contain 2 mg/mL Co and Ni, 1.0 mg/mL Cs, Mn, Fe, and Ce. Transfer the following into a 250 mL beaker:

9.91 g $Ni(NO_3)_2 \cdot 6H_2O$ (Nickel nitrate), and
7.24 g $Fe(NO_3)_3 \cdot 9H_2O$ (Ferric nitrate), and
3.60 g $MnCl_2 \cdot 4H_2O$ (Manganese chloride), and
8.07 g $CoCl_2 \cdot 6H_2O$ (Cobalt chloride), and
2.34 g $Ce(NO_3)_3 \cdot 6H_2O$ (Cerous nitrate)
1.27 g CsCl (Cesium chloride)

Add fifty mL of water and 5 mL of 8 M nitric acid. Warm gently until everything has dissolved, then transfer quantitatively to a 1 liter volumetric flask. Bring the volume to 1000.0 mL mark, mix well, then pour into a storage bottle without rinsing the volumetric flask.

Reagents for milk only:

Cation Exchange Resin - Dowex 50W-X8 (Na form), 50-100 mesh size, available from Bio-Rad Laboratories. (The commercially available H^+ form is converted into the Na^+ form by mixing 1.5l of 4M NaCl and 200 mL of resin on a magnetic stirrer for 30 minutes. The resin is filtered in a large Buchner funnel and washed with deionized water until the wash water is Cl-free when tested with 10% $AgNO_3$. If a white AgCl precipitated forms, additional water washings are necessary. It is advantageous to prepare enough resin for several samples ahead of time.)

4M NaCl: 234 g NaCl dissolved in a 1 liter graduated mixing cylinder in distilled water, then diluted to 1 liter.

10% AgNO3 Silver Nitrate: 50 grams of $AgNO_3$ dissolved in 500 mL of deionized water. Store in dark bottle, away from light.

Equipment and Materials

Beakers, 2 liter, 1 liter, 250 mL
Centrifuge
Centrifuge tubes, 100 mL plastic and/or glass, 50 mL conical bottom
Hot plate
Heat lamp
Meeker burner

Magnetic stirrer and stirring bar
Filter paper 7 cm GFA, Whatman #42 12.5 cm
Buchner funnel, 7 cm
Funnel, 60°
Side arm flask, 1000 mL
125 mL separatory funnel and stopper
Wrist action shaker
Platinum crucible, 150 mL
Muffle furnace 500°C, 1000°C
Stainless steel planchet 1 1/2", 1" and cardboard holders
Plastic jar 250 mL or plastic vial, 25 mL
Balance, 100 g

Calculation of Strontium Activities in Urine, Feces, and Environmental Matrices

The calculations for manual mode or computer mode (CALCTL for ERA samples, PERCTL for BA samples) are basically the same except that in the manual mode, results obtained should be considered as tentative, as only the uncertainty from counting statistics are considered.

If the program is not available, use the following calculation:

Sr-89 or Sr-90 decay corrected value =

(Sr-89 or Sr-90 reference value) x $e^{-K\,t}$

where:

t = difference in reference date and current date

"K" = decay constant for Sr-89 and Sr-90, expressed in the same time units as "t" = $.693/t_{1/2}$.

1. Total strontium activity of the sample and the corresponding counting uncertainty are calculated as follows:

Sr (Total) dpm per sample or pCi per unit =

$$\frac{(C_1 - B)((dpc)_{Tot}) \times [V \text{ or } W]}{[2.22] \times Y_S \times (V_A \text{ or } W_A)}$$

Counting Uncertainty dpm or [pCi] per unit or [sample] =

$$\frac{[2] \times SQR\ (C_1/T_1 + B/T_B) \times (dpc)_{Tot} \times [V \text{ or } W]}{[2.22] \times Y_s \times (V_A \text{ or } W_A)}$$

where:

[ ] = The square brackets indicate parameters exclusively used for environmental or bioassay analyses only.

$(dpc)_{Tot}$ = Disintegrations per count value corresponding to the weight of $Sr(NO_3)_2$ in mg from the dpc table. Sr-89 and Sr-90 activities are assumed to contribute equally to the total activity.

C_1 = Gross cpm from the first strontium count

T_1 = Sample counting time in minutes

B = Background cpm

T_B = Background counting time in minutes

Y_s = Chemical recovery of strontium expressed as a decimal

[V or W] = Volume or weight of the sample in the same units as V_A or W_A (applicable for bioassay samples only)

V_A or W_A = Volume or weight of the aliquot in the required unit

2.22 = Factor for conversion of activity from dpm to pCi (only for environmental samples)

[2] = Two sigma uncertainty reported for environmental samples only

2. <u>Sr-90 activity of the sample and the corresponding counting uncertainty from the Y-90 milking is calculated as follows:</u>

Sr-90 dpm per sample or pCi per unit =

$$\frac{(C_Y - B) \times e^{K_2 t_2} \times (dpc)_{Y_2} \times [V \text{ or } W]}{[2.22] \times I \times Y_s \times Y_y \times V_A \text{ or } W_A}$$

Counting Uncertainty dpm per sample or pCi per unit =

$$\frac{[2] \times SQR\,(C_Y/T_Y + B/T_B) \times e^{K_2 t_2} \times (dpc)_{Y_2} \times [V \text{ or } W]}{[2.22] \times I \times Y_s \times Y_y \times V_A \text{ or } W_A}$$

where:

[ ] = parameters exclusively used for environmental or bioassay analysis

C_Y = Gross Y-90 cpm

T_Y = Time of Y-90 counting in minutes

B = Background cpm

T_B = Length of background counting in minutes

$e^{K_2 t_2}$ = Correction for the decay of Y-90 during the time (t_2 hours) elapsed between Y-90 milking and counting. "K" is the decay constant for Y-90 = 0.693/64.1 hours.

$(dpc)_{Y_2}$ = Disintegrations per count of Y-90 corresponding to the weight of yttrium oxide and the counter used

[V or W] = Volume or weight of the total sample in the same units as V_A or W_A for Bioassay only

V_A or W_A = Volume or weight of the sample aliquot in the units required

[2.22] = Factor, dpm or pCi (Applicable for environmental samples only)

I = Correction for the fractional ingrowth of Y-90 in the strontium sample at the time of milking (from the table)

Y_s = Gravimetric recovery of strontium as strontium carbonate

Y_y = Gravimetric recovery of yttrium oxide (weight of final Y_2O_3 precipitated (mg)/25.4 mg expected).

3. Sr-89 Determination: Sr-89 activity is determined by subtracting Sr-90 activity and Y-90 ingrowth, which are estimated from Y-90 milking and determination, from the total strontium activity observed during the first strontium count with appropriate corrections for self absorption, scattering, and counting efficiency.

Sr-89 dpm per sample or pCi per unit =

$$\frac{\left[(C_1 - B) - \frac{(dpm)_{S90}}{(dpc)_{S90}} - \frac{(dpm)_{S90}}{(dpc)_{Y1}} * (1 - e^{-K_1 t_1})\right] \times (dpc)_{S89} \times e^{K_3 t_3} \times V \text{ or } W}{[2.22] \times Y_S \times V_A \text{ or } W_A}$$

where:

[ ]	= Parameters exclusive for environmental or bioassay analyses
$(dpm)_{S90}$	= Disintegrations per minute of Sr-90 nominal value before correcting for factors, such as 2.22, Y_s, volume and weight terms as shown below: $\frac{(C_y - B) * e^{K_2 t_2} * (dpc)_{Y2}}{I * Y_y}$
$(dpc)_{S90}$, $(dpc)_{Y1}$, $(dpc)_{S89}$	= Disintegration per count of Sr-90, Y-90, and Sr-89 respectively corresponding to the counter used and the weight of strontium carbonate.
$(1 - e^{-K_1 t_1})$	= Factor expressing Y-90 ingrowth in the strontium sample during the time (t_1 in hours) elapsed between the time "t_0" of the first Y-90 removal from the strontium sample and the first (strontium) count. "K_1" is the decay constant for Sr-90 = .693/28.8 years.
2.22	= Factor, dpm per pCi - for environmental samples only.
[V or W]	= Volume or weight of the sample in the same units as V_A or W_A - only for Bioassay analysis.

$e^{K_3 t_3}$ = Correction for the decay of Sr-89 from the date of first strontium counting to the sample date. "K_3" is the decay constant for Sr-89 = 0.693/50.5 days.

Counting Uncertainty dpm per sample or pCi per unit =

$$\frac{[2] \times SQR\left(C_1/T_1 + B/T_B + \dfrac{E_{S90}^2}{(dpc)_{S90}^2} + \dfrac{E_{S90}^2(1 - e^{-K_1 t_1})^2}{(dpc)_{Y_1}^2}\right) \times (dpc)_{Sr89} \times e^{K_3 t_3} \times [V \text{ or } W]}{[2.22] \times Y_S \times V_A \text{ or } W_A}$$

where:

$$E_{S90} = \frac{SQR(C_Y/T_Y + B/T_B) \times e^{K_2 t_2} \times (dpc)_{Y_2}}{I \times Y_Y}$$

All the known uncertainties are propagated using a computer program.

PRE-SEPARATION:

Milk

1(M). Add 100 cc of Dowex 50W-X8 resin (Na-form) equilibrated as described in the reagent section, to the milk sample aliquots and stir for 3 hours using a magnetic stirrer. Allow the resin to settle for 5-10 minutes. Decant as much of the milk as possible into a separate beaker without losing any resin.

2(M). Add about 500 mL of D.I. Water to the resin beaker and stir for about one minute using magnetic stirrer. Allow the resin to settle, decant and discard the supernate. Repeat this process until visible milk solids (cloudiness) have been removed from the resin.

3(M). Add 400 mL of 4M NaCl to the resin sample and stir for 15 minutes. Allow the resin to settle and filter through a 7-Cm GFA filter and collect the filtrate in a 1000 mL Erlynmeyer flask. Transfer the NaCl solution from the flask to a clean 1000 mL beaker. Transfer the resin from the filter reservoir back to the resin beaker, add 200 mL of 4M NaCl, stir for 15 min., filter under is before vacuum and rinse the resin with H_2O, collect the filtrate in the 1000 mL Erlynmeyer flask. Add the second NaCl solution and rinse from the flask to the 1000 mL beaker containing the first NaCl solution as wash solution. Discard the resin to waste.

4(M). Add 2-3 drops of phenolphthalein indicator to the NaCl solution, then add conc NH_4OH while stirring until the solution turns pink (end point). Add 70-100 mL of saturated Na_2CO_3, and heat for 10 minutes, then cool to room temperature. Decant most of the supernate to waste. Centrifuge to collect the precipitate remaining.

5(M). Proceed to the <u>Strontium Determination Section</u>.

KEYPOINT: Exercise extreme caution when performing the fuming nitric acid step since a vigorous reaction is possible if any resin is remaining.

<u>Soil</u>

1(S). Evaporate the 8M HNO_3 sample leachate to dryness, then add about 5 mL conc. HCl and carefully evaporate to near dryness at least two times.

2(S). Dissolve the sample in 9M HCl, transfer to a separatory funnel, add about 20 mL of isopropyl ether and shake with frequent venting for 1-2 minutes. Reject the ether (upper phase). Repeat the isopropyl ether extraction two more times or until the yellowish tint indicating iron does not appear in the ether phase.

3(S). Transfer 9M HCl phase back to the original beaker and evaporate to dryness. Convert the sample back to the nitric media using 2-10 mL additions of conc. nitric acid and cooperating to dryness after each addition.

4(S). Proceed to step one of the <u>Strontium Determination Section</u>.

<u>Water</u>

1(W). Add saturated Na_2CO_3 directly to the water sample or to the water sample that has been concentrated by evaporating and allow the precipitate to settle <u>overnight</u>. Decant most of the supernate to waste and collect the precipitate in a centrifuge tube. Dissolve the precipitate in about 5 mL of 2M HNO_3, dilute to 20 mL with D.I. H_2O and proceed to step 4 of the Strontium Determination Section.

Urine and Feces

1(U). Dissolve sample salts by adding about 50 mL of D.I. water, warm and add 5 to 10 mL of conc. HNO_3. Add phenolphthalein indicator, and adjust to the red end point using concentrated NH_4OH. Add 25 mL of saturated Na_2CO_3, heat for 2-5 min. (metathesis), then cool for 10 minutes.

2(U). Transfer, using D.I. water to 1 or 2 100 mL plastic centrifuge tubes and allow the sample to cool for at least 1/2 hour. Centrifuge and decant the supernate to waste. Add about 30-40 mL of D.I. Water. Stir, centrifuge, and decant the supernate to waste.

3(U). Proceed to the Strontium Determination Section.

Ion Exchange Resin Samples

1(R). A prepared amount (see 30-20-01) of strontium-85 and strontium carrier is added to the sample in its original container. Add a small amount of deionized water, cap the container and shake vigorously. Transfer the sample quantitatively to a 600 mL beaker (labeled with a Tech pen) with DI water followed by a rinse with about 5 mL of concentrated nitric acid. The entire sample is again mixed with a stirrer and dried under a heat lamp.

2(R). The sample is ashed to a pinkish white residue at 500-550°C in a muffle furnace (process may take up to a week or more) and then transferred quantitatively to a platinum crucible. Na_2CO_3 is added in an amount equal to 4-5 times that of the sample weight and mixed in thoroughly. The mixture is fused at 900-1000°C for approximately 1-2 hours.

3(R). The platinum crucible is placed in a 600 mL beaker and the fusion mixture is dissolved with approximately 200 mL of hot water. The platinum crucible is removed and rinsed with a minimum of 6M HCl.

4(R). Approximately 25 mL of sat. Na_2CO_3 is added to the sample with stirring. After allowing the precipitate to settle the majority of the supernate is decanted to waste and the remaining is centrifuged. Proceed with the strontium carbonate precipitate to the Strontium Determination Section.

STRONTIUM DETERMINATION

SPECIAL SAFETY PRECAUTION: Fuming nitric acid is used in this procedure. It can be hazardous; especially when brought in contact with organics, therefore exercise extreme care.

All waste fractions are generally saved to the end of the procedure; after acceptable recoveries are received they may be discarded.

1. Dissolve the sample residue or carbonate precipitate in a minimum amount of HNO_3 while stirring. Add 50-70 mL of fuming nitric acid and cool in an ice bath for 20-30 minutes. Centrifuge and save the supernate for Sequential Analysis if requested; proceed to the plutonium procedure (20-Pu-01) with this fraction.

   The fuming nitric acid addition may be done in a beaker first, then transferred to centrifuge tubes, especially in the case of soil and vegetation.

   KEY POINT: The fuming nitric precipitation is an excellent separation point for sequential chemistry and is usually included in the sample preparation chemistry (30-ENV-SP).

2. To the precipitate, add 30-40 mL of conc. HNO_3 to remove excess calcium. Stir, centrifuge and decant to waste. Repeat one or more times depending on the calcium content of the particular matrix.

3. Add 20-30 mL of warm D.I. water. Stir to dissolve completely. If any insoluble material is present separate this precipitate by centrifuging and decanting the supernate to a clean centrifuge tube.

   For Vegetation Samples (or any other sample that has been muffled) when insoluble residue remains after dry washing: (metathesis) Transfer the insoluble material to a beaker with 2M HNO_3, add excess Na_2CO_3 and boil for 15 minutes. Transfer back to the tube, centrifuge and decant supernate to waste. Dissolve precipitate in 5-15 mL conc. HNO_3, warm, stir, centrifuge and combine this supernate with the water soluble fraction.

   KEY POINT: Insoluble material not undergoing metathesis should be retained until an acceptable final precipitate weight recovery or tracer recovery is established, then it can be discarded.

4. Add 1-2 drops of phenolphthalein indicator and adjust dropwise just to Basic (pink endpoint) using conc. NH_4OH, then add 5 drops in excess. Add 1 or 2 drops of mixed (hold back) carrier, allow iron and other metal hydroxides to flocculate. Centrifuge and transfer the supernate to a clean centrifuge tube. Rinse the precipitate with 10 mL of D.I. water centrifuge and combine the supernates.

5. Add 10 mL of freshly prepared buffer solution prepared by mixing equal amounts of 1.5M acetic acid and 3M ammonium acetate. Add 2-3 drops of methyl red indicator and adjust the pH to about 5.0, straw color of methyl red, using glacial acetic acid or conc. NH_4OH. Heat for 5-10 min. then add 1 mL of barium carrier and 1 mL of 1.5M Na_2CrO_4 and continue heating for 5-10 min.

6. Centrifuge and/or filter the $BaCrO_4$ through a 2" 60° funnel (using Whatman #42 filter paper) into a clean centrifuge tube. Rinse the filter with D.I water. Fill the centrifuge tube or tubes with saturated Na_2CO_3, centrifuge, and decant the supernate to waste.

   KEY POINT: Centrifuge only if the $BaCrO_4$ precipitate appears to be heavy, otherwise filter.

   For vegetation, soil and filter samples. Dissolve the precipitate in a minimum of 2M HNO_3 and repeat steps 4, 5, and 6.

7. Add fuming HNO_3 dropwise to the precipitate until the effervescence has ceased, then add 50 mL of fuming HNO_3 and cool in the ice water bath for 5-10 minutes. Centrifuge and decant the supernate to waste.

   KEY POINT: Add the fuming nitric very slowly at first to avoid sample loss due to the effervescense.

8. Wash the sample one or more times using 20-30 mL of conc. HNO_3 depending on sample matrix. High calcium content matrices may require up to 3 nitric acid washes. Record the Sr-Y separation time on the counting request card.

   KEY POINT: 1. If an unusually large precipitate does not appear to diminish in size after two conc HNO_3 washes discontinue further washes and check with your supervisor.

2. The time of the last nitric acid wash should be considered the separation time.

9. If Sr-85 tracer was added, dissolve the sample precipitate in D.I. H_2O and transfer to 25 mL volume in a styrene jar or 20 mL volume in a plastic (scintillation) vial and submit for a gamma count for Sr-85 recovery.

10. If only Sr (cold) carrier was added, dissolve the precipitate in 10 mL of H_2O, add 25-50 mL of saturated Na_2CO_3, warm for 5-10 minutes, centrifuge, and discard the supernate. Wash the precipitate twice with 20-30 mL D.I. H_2O, centrifuge and discard the wash. Slurry the strontium carbonate precipitate with 1-2 mL of D.I. H_2O and transfer quantitatively to a tared 1" or 1 1/2" stainless steel planchet. Dry under infrared lamp. Cool, weigh, and record on the request card and beta count on either a Low Beta (plated on 1 1/2" planchet) or a Quad Low Background Beta proportional counter (plated on 1" or 1 1/2" planchet).

11. Allow up to 14 days to permit Y-90 to grow into equilibrum with the Sr-90 (the ingrowth time may be shortened if necessary provided a growth correction is made).

STRONTIUM-90 (BY YTTRIUM-90)

12. Using 2M HNO_3, carefully dissolve and rinse the strontium carbonate precipitate from the planchet into a 50-mL centrifuge tube. If Sr-85 yield determination was performed, transfer from the Styrene jar or plastic and to a 100-mL tube. Transfer one Yttrium carrier vial containing exactly 1 mL of Yttrium carrier (20.0 mg Y/mL). Rinse the vial with D.I. water, stir and let stand for 10 minutes.

13. Add 12M NaOH until a permanent clear gelatinous precipitate forms, then add 2 to 3 mL excess and decant supernate to a Styrene jar for possible re-milk. Stir, centrifuge for 5 minutes. Note the Yttrium separation date and time on the analysis request card.

14. Dissolve the precipitate with (1-2 mL) of conc. HNO_3, dilute to approximately 25-30 mL with water, then add conc. NH_4OH (approximately 15 mL) until a permanent precipitate forms. Add 2 to 3 mL excess NH_4OH, stir, centrifuge for 5 minutes and decant the supernate to waste.

15. Repeat Step #14 then wash the precipitate with 25 mL of water, centrifuge for 5 minutes and decant the supernate to waste.

16. Dissolve the precipitate using 1 mL of conc. HCl, then add 40 mL of boiling hot 15% oxalic acid solution and let stand for 5 to 10 minutes. Centrifuge for 5 minutes and decant and discard the supernate. Wash the oxalate precipitate twice with 10 mL of water, centrifuge for 5 minutes and decant and discard the supernate.

17. Transfer the precipitate with water to a previously flamed, labeled, and tared 1" or 1 1/2" stainless steel planchet (depending on the beta counter to be used) with a plastic transfer pipet and dry under a heat lamp. Ignite slowly over a Meker burner to convert the oxalate to the oxide. Cool, weigh and record weight on the request card, fix the sample to the planchet with collodion (2 or 3 drops), and submit for a beta proportional count.

LAST PAGE

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Mathew M Landy 2/6/86

Al Robinson 2/4/86

REFERENCE 2

Computer Printouts from Hanford Ground Water Data Base

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NETPRINT

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File [illegible]:[]100.TMP;7 (4227,77,0), last revised on 14-AUG-1987 10:41, is a 32 block sequential file owned by UIC [NETPRINT]. The records are variable length with implied (CR) carriage control. The longest record is 0 bytes.

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WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR	
~~1-H3-1~~	~~5/21/87~~	~~FCHROM~~		~~6.2000E+01~~	~~H~~	DG for Chromium
~~1-H5-12~~	~~3/25/87~~	~~FCHROM~~		~~1.5500E+03~~	~~H~~	DG " "
~~1-K-21~~	~~5/18/87~~	~~FCHROM~~		~~1.3700E+02~~	~~H~~	DG " "

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR	
~~1-H4-4~~	~~4/10/87~~	~~SR 90~~		~~0.0500E+00~~	~~B~~	DG for ^{90}Sr
~~1-N-4~~	~~5/29/87~~	~~SR 90~~		~~1.2500E+01~~	~~H~~	DG for ^{90}Sr

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
1-H4-5	4/10/87	1,1,1-T	<	1.0000E+01	H
1-H4-5	4/10/87	1,1,2-T	<	1.0000E+01	H
1-H4-5	4/10/87	ALUMNUM	<	1.5000E+02	H
1-H4-5	4/10/87	AMMONIU	<	5.0000E+01	H
1-H4-5	4/10/87	ANTIONY	<	1.0000E+02	H
1-H4-5	4/10/87	ARSENIC	<	5.0000E+00	H
1-H4-5	4/10/87	BARIUM		5.0000E+01	H
1-H4-5	4/10/87	BERYLUM	<	5.0000E+00	H
1-H4-5	4/10/87	BETA		8.7100E+00	H
1-H4-5	4/10/87	CADMIUM	<	2.0000E+00	H
1-H4-5	4/10/87	CALCIUM		6.0300E+04	H
1-H4-5	4/10/87	CHLFORM	.	2.0000E+01	H
1-H4-5	4/10/87	CHLORID		6.5300E+03	H
1-H4-5	4/10/87	CHROMUM		1.7700E+02	H
1-H4-5	4/10/87	CO 60	<	-1.6000E+00	B
1-H4-5	4/10/87	COLIFRM	<	2.2000E+00	H
1-H4-5	4/10/87	CONDUCT		4.1400E+02	H
1-H4-5	4/10/87	COPPER	<	1.0000E+01	H
1-H4-5	4/10/87	CS-137	<	3.6600E+00	B
1-H4-5	4/10/87	FALUMIN	<	1.5000E+02	H
1-H4-5	4/10/87	FANTIMO	<	1.0000E+02	H
1-H4-5	4/10/87	FARSENI	<	5.0000E+00	H
1-H4-5	4/10/87	FBARIUM		5.5000E+01	H
1-H4-5	4/10/87	FBERYLL	<	5.0000E+00	H
1-H4-5	4/10/87	FCADMIU	<	2.0000E+00	H
1-H4-5	4/10/87	FCALCIU		5.7000E+04	H
1-H4-5	4/10/87	FCHROMI		1.6000E+02	H
1-H4-5	4/10/87	FCOPPER	<	1.0000E+01	H
1-H4-5	4/10/87	FIRON	<	5.0000E+01	H
1-H4-5	4/10/87	FLEAD	<	5.0000E+00	H
1-H4-5	4/10/87	FLUORID	<	5.0000E+02	H
1-H4-5	4/10/87	FMAGNES		1.0300E+04	H
1-H4-5	4/10/87	FMANGAN	<	5.0000E+00	H
1-H4-5	4/10/87	FMERCUR	<	1.0000E-01	H
1-H4-5	4/10/87	FNICKEL	<	1.0000E+01	H
1-H4-5	4/10/87	FOSMIUM	<	3.0000E+02	H
1-H4-5	4/10/87	FPOTASS		4.6700E+03	H
1-H4-5	4/10/87	FSELENI	<	5.0000E+00	H
1-H4-5	4/10/87	FSILVER	<	1.0000E+01	H
1-H4-5	4/10/87	FSODIUM		1.0300E+04	H
1-H4-5	4/10/87	FSTRONT	<	3.0000E+02	H

1-11-5	4/10/87	FJAIANI		5.0000E+00	H
1-11-5	4/10/87	FZINC		4.2000E+01	H
1-11-5	4/10/87	IRON		5.0000E+01	H
1-11-5	4/10/87	LEADGF	<	5.0000E+00	H
1-11-5	4/10/87	LOALPHA		2.3400E+00	H
1-11-5	4/10/87	M-XYLE	<	1.0000E+01	H
1-11-5	4/10/87	MAGNES		1.0400E+04	H
1-11-5	4/10/87	MANGESE	<	5.0000E+00	H
1-11-5	4/10/87	MERCURY	<	1.0000E-01	H
1-11-5	4/10/87	METHONE	<	1.0000E+01	H
1-11-5	4/10/87	METHYCH	<	1.0000E+01	H
1-11-5	4/10/87	NICKEL	<	1.0000E+01	H
1-11-5	4/10/87	NITRATE		2.8700E+04	H
1-11-5	4/10/87	OPXYLE	<	1.0000E+01	H
1-11-5	4/10/87	OSMIUM	<	3.0000E+02	H
1-11-5	4/10/87	PERCENE	<	1.0000E+01	H
1-11-5	4/10/87	PH		7.3300E+00	H
1-11-5	4/10/87	PHOSPHA	<	1.0000E+03	H
1-11-5	4/10/87	POTASUM		4.5500E+03	H
1-11-5	4/10/87	RADIUM	<	3.4700E-02	H
1-11-5	4/10/87	RU 106	<	-1.9300E+01	B
1-11-5	4/10/87	SELENUM	<	5.0000E+00	H
1-11-5	4/10/87	SILVER	<	1.0000E+01	H
1-11-5	4/10/87	SODIUM		1.1000E+04	H
1-11-5	4/10/87	SR 90	<	7.5300E-01	B
~~1-11-5~~	~~4/10/87~~	~~STRONTIUM~~	~~<~~	~~3.0000E+02~~	~~H~~
1-11-5	4/10/87	SULFATE		5.7700E+04	H
1-11-5	4/10/87	TETRANE	<	1.0000E+01	H
1-11-5	4/10/87	TOC	<	8.6500E+02	H
1-11-5	4/10/87	TOX	<	1.0000E+02	H
1-11-5	4/10/87	TRICENE	<	1.0000E+01	H
1-11-5	4/10/87	TRITIUM		1.0700E+03	B
1-11-5	4/10/87	U		2.0700E+00	B
1-11-5	4/10/87	VANADIUM		5.0000E+00	H
1-11-5	4/10/87	ZINC		4.8000E+01	H

BKG for ^{90}Sr

9 9 ? 1 0 ? ?

WELL NAME	COLLECTION DATE	CONSTITUENT NAME	LESS THAN FLAG	ANALYSIS VALUE	ANALYSIS SPONSOR
6-77-54	6/12/87	1,1,1-T	<	1.0000E+01	H
6-77-54	6/12/87	1,1,2-T	<	1.0000E+01	H
6-77-54	6/12/87	1,1-DIH	<	3.0000E+03	H
6-77-54	6/12/87	1,2-DIH	<	3.0000E+03	H
6-77-54	6/12/87	12-Dben	<	1.0000E+01	H
6-77-54	6/12/87	1234TE	<	1.0000E+01	H
6-77-54	6/12/87	1235TE	<	1.0000E+01	H
6-77-54	6/12/87	123TRI	<	1.0000E+01	H
6-77-54	6/12/87	13-Dben	<	1.0000E+01	H
6-77-54	6/12/87	135TRI	<	1.0000E+01	H
6-77-54	6/12/87	14-Dben	<	1.0000E+01	H
6-77-54	6/12/87	ACETILE	<	3.0000E+03	H
6-77-54	6/12/87	ACRYIDE	<	3.0000E+03	H
6-77-54	6/12/87	ALKALIN		1.1000E+05	H
6-77-54	6/12/87	ALLYLAL	<	3.0000E+03	H
6-77-54	6/12/87	AMMONIU	<	5.0000E+01	H
6-77-54	6/12/87	BETA		8.5100E+00	H
6-77-54	6/12/87	CHLACET	<	3.0000E+03	H
6-77-54	6/12/87	CHLFORM	<	1.0000E+01	H
6-77-54	6/12/87	CHLORAL	<	3.0000E+03	H

Ref. 2.3

9 1 1 1 8 9 2 1 0 2 3

6-77-54	6/12/87	CHLORID		5.7100E+03	H
6-77-54	6/12/87	CHLPROP	<	3.0000E+03	H
6-77-54	6/12/87	CONDUCT		2.7300E+02	H
6-77-54	6/12/87	CYANBRO	<	3.0000E+03	H
6-77-54	6/12/87	CYANCHL	<	3.0000E+03	H
6-77-54	6/12/87	CYANOGN	<	3.0000E+03	H
6-77-54	6/12/87	DICPROP	<	3.0000E+03	H
6-77-54	6/12/87	ETHCARB	<	3.0000E+03	H
6-77-54	6/12/87	ETHCYAN	<	3.0000E+03	H
6-77-54	6/12/87	ETHOXID	<	3.0000E+03	H
6-77-54	6/12/87	FALUMIN	<	1.5000E+02	H
6-77-54	6/12/87	FANTIMO	<	1.0000E+02	H
6-77-54	6/12/87	FARSENI	<	5.0000E+00	H
6-77-54	6/12/87	FBARIUM		2.4000E+01	H
6-77-54	6/12/87	FBERYLL	<	5.0000E+00	H
6-77-54	6/12/87	FCADMIU	<	2.0000E+00	H
6-77-54	6/12/87	FCALCIU		3.5000E+04	H
6-77-54	6/12/87	FCHROMI	<	1.0000E+01	H BKG for Chromium
6-77-54	6/12/87	FCOPPER	<	1.0000E+01	H
6-77-54	6/12/87	FIRON	<	5.0000E+01	H
6-77-54	6/12/87	FLUORID		5.0400E+02	H
6-77-54	6/12/87	FLUORA	<	3.0000E+03	H
6-77-54	6/12/87	FMAGNES		1.1600E+04	H
6-77-54	6/12/87	FMANGAN	<	5.0000E+00	H
6-77-54	6/12/87	FMERCUR	<	1.0000E-01	H
6-77-54	6/12/87	FNICKEL	<	1.0000E+01	H
6-77-54	6/12/87	FOSMIUM	<	3.0000E+02	H
6-77-54	6/12/87	FPOTASS		4.0100E+03	H
6-77-54	6/12/87	FSELENI	<	5.0000E+00	H
6-77-54	6/12/87	FSILVER	<	1.0000E+01	H
6-77-54	6/12/87	FSODIUM		1.5400E+04	H
6-77-54	6/12/87	FSTRONT	<	3.0000E+02	H
6-77-54	6/12/87	FVANADI		2.7000E+01	H
6-77-54	6/12/87	FZINC		1.0000E+01	H
6-77-54	6/12/87	GLYCIDY	<	3.0000E+03	H
6-77-54	6/12/87	HEXACHL	<	1.0000E+01	H
6-77-54	6/12/87	HEXCHEN	<	1.0000E+01	H
6-77-54	6/12/87	HYDRAZI	<	3.0000E+03	H
6-77-54	6/12/87	ISOBUTY	<	3.0000E+03	H
6-77-54	6/12/87	KEROSEN	<	1.0000E+04	H
6-77-54	6/12/87	LOALPHA		1.0900E+00	H
6-77-54	6/12/87	M-XYLE	<	1.0000E+01	H
6-77-54	6/12/87	METHONE	<	1.0000E+01	H
6-77-54	6/12/87	METHYCH	<	1.0000E+01	H
6-77-54	6/12/87	NETZINE	<	3.0000E+03	H
6-77-54	6/12/87	NAPHTHA	<	1.0000E+01	H
6-77-54	6/12/87	NITRATE		7.9600E+03	H
6-77-54	6/12/87	OPXYLE	<	1.0000E+01	H
6-77-54	6/12/87	PARALDE	<	3.0000E+03	H
6-77-54	6/12/87	PENTCHL	<	1.0000E+01	H
6-77-54	6/12/87	PERCENE	<	1.0000E+01	H
6-77-54	6/12/87	PH		7.3000E+00	H
6-77-54	6/12/87	PH		7.6400E+00	H
6-77-54	6/12/87	PHENOL	<	1.0000E+01	H
6-77-54	6/12/87	PHOSPHA	<	1.0000E+03	H
6-77-54	6/12/87	PROPYLA	<	3.0000E+03	H
6-77-54	6/12/87	PROPYNO	<	3.0000E+03	H
6-77-54	6/12/87	SULFATE		4.1500E+04	H
6-77-54	6/12/87	TETRANE	<	1.0000E+01	H
6-77-54	6/12/87	TETRCHB	<	1.0000E+01	H
6-77-54	6/12/87	TOC	<	4.4500E+02	H
6-77-54	6/12/87	TOXLOL	<	1.6300E+00	H
6-77-54	6/12/87	TRICENE	<	1.0000E+01	H

Ref. 2.4

REFERENCE 3

Hanford Wells, PNL-5397, February 1985

WELL DESIGNATION / EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
199 H3 1 1890	N 094994 P W 040052	421.90	75	45	8.0	75	29 - 74	8-60		SAMPLE PUMP
199 H4 1 1875	N 095700 P W 038400	417.75	75		6.0	38	25 - 50	3-52	107-H-1	CASING REMOVED
199 H4 2 1876	N 095200 P W 038565	420.43	386	3	6.0	311	25 - 50	5-52	107-H-2	CONFINED AQUIFER
199 H4 3 1877	N 096373 P W 039080	420.35	55	39	6.0	55	34 - 55	5-74		SAMPLE PUMP
199 H4 4 1878	N 093560 P W 038685	413.76	55	36	6.0	50		6-83		SCREEN 33-43 GROUTED SAMPLE PUMP
199 H4 5 1873	N 096639 P W 039065	416.26	60	36	6.0			5-83		SCREEN 32-42 GROUTED SAMPLE PUMP
199 H4 6 1874	N 096473 P W 040245	419.58	55	41	6.0	54		5-83		SCREEN 39-49 GROUTED SAMPLE PUMP

Ref. 3.1

9 1 1 1 8 9 7 1 0 2 5

WELL DESIGNATION EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
199 N 1 1908	N 086157 P W 060593	456.10	100	54	8.0	62	34 - 95	5-64		
O		456.37	60	50	1.50		40 - 60	10-64		
P		456.38	90	55	1.50		88 - 90	10-64		
Q		456.36	74	55	1.50		72 - 74	10-64		
199 N 2 1904	N 086577 P W 060306	459.83	125	57	8.0	95	35-120	6-64		PLUG AT 95
O		460.10	76	57	1.50		60 - 70	10-64		
P		460.10	122	57	1.50	132	112-122	10-64		
Q		460.10	107	61	1.50		105-107	10-64		
R		460.10	79		1.50		77 - 79	10-64		
199 N 3 1896	N 086365 P W 060828	459.45	125	63	8.0	70	34 - 95	6-64		SAMPLE PUMP
O		459.72	68		1.50		60 - 68	10-64		REMOVED
P		459.71	122		1.50		112-122	10-64		REMOVED
Q		459.72	98		1.50		96 - 98	10-64		REMOVED
R		459.71	80		1.50		78 - 80	10-64		REMOVED
199 N 4 1899	N 085921 P W 060042	458.73	150	52	8.0	73	50 - 60	6-64		CEMENT BRIDGE @73 FT SAMPLE PUMP
O		457.90	63	54	1.50		50 - 60	4-64		REMOVED 6-74
P		457.90	138		1.50		128-138	10-64		REMOVED 6-74
Q		457.90	123		1.50		113-123	10-64		REMOVED 6-74
R		457.90	105		1.50		103-105	10-64		REMOVED 6-74
S		457.90	78		1.50		76 - 78	10-64		REMOVED 6-74

Ref. 3.2

91118901027

WELL DESIGNATION / EAA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
699 73 33A	P N 074590 W 023350	379.07	35		6.0	35		5-43	HR-11	FILLED IN WITH SILT
699 73 33B	P N 074690 W 023370	380.00	36		6.0	36		5-43	HR-12	FILLED IN WITH SILT
699 76 34		375.01	19		24.0	19		0- 0	REF.2 NO.70	FILLED IN
699 76 50		414.00	41		36.0			0- 0	13/25-3D1 REF.7	DUG WELL
699 77 34	P N 076925 W 034275	397.24	21		72.0	21		0- 0	T14N R27E 32-Q1	FILLED IN
699 77 36 4500	P N 076700 W 036150	412.28	150	35	8.0	82	32 - 82	4-57		CEMENT PLUG AT 82FT SAMPLE PUMP
699 77 43	P N 076600 W 042500	441.37	44		72.0	44		0- 0	REF.2 NO.74 S1610	FILLED IN
699 77 54 4512	P N 076700 W 054100	480.59	150	84	8.0	118	70 -120	5-57		CEMENT PLUG AT 120FT SAMPLE PUMP
699 78 36 4489		485.00	38		48.0			0- 0	REF.2 NO.20 N.RUN NO.4	FILLED IN FARM WELL
699 78 45	P N 078050 W 044625	432.00	36		60.0			0- 0	REF.2 NO.111	FILLED IN
699 78 62 4511	P N 077750 W 062300	469.00	150	76	8.0	109	70 -120	5-57		#15 SCREEN 67-107 FT SAMPLE PUMP
699 79 104		774.00	699	370	16.0	703	429-678	2-53	PSN 515 14/25-31M1	ARMY CAMP WELL

Ref. 3.3

WELL DESIGNATION / EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
199 B3 1 P 1851	N 071000 W 079830	439.79	63	46	8.0	63	20 - 60	3-53	107-B-1	SAMPLE PUMP
199 B3 2 P 1852	N 071752 W 078810	442.59	790	20	8.0	768	635-645	8-53	107-B-2	
1856 P		443.30	770		1.50		758-770	3-70		
1857 Q		442.81	642	42	1.50	429	632-642	3-70		
199 B4 1 P 1853	N 070000 W 080650	461.80	90	65	8.0	83	50 - 90	2-49	108-B-1	SAMPLE PUMP
199 B4 2 P 1854	N 069933 W 080672	461.99	90	63	6.0	86	62 - 90	2-49	108-B-2	PLUG AT 86
199 B4 3 P 1855	N 069933 W 080636	461.75	91	63	8.0	86	60 - 90	2-49	108-B-3	PLUG AT 86
199 B4 4 P 1891	N 068978 W 080367	472.14	105	76	8.0	96	49 -102	9-60		SAMPLE PUMP
199 B5 1 P 1895	N 069930 W 082080	455.56	151	58	8.0	100	40 -140	8-62		PLUG AT 100
199 B8 1 P	N 067375 W 080490	494.59	75		8.0	76	NONE	3-51	C431-1	NOT ACCESSIBLE
199 B8 2 P	N 067400 W 080800	495.59	25		8.0	26	NONE	4-51	C431-2	CASING REMOVED
199 B8 3 P	N 067455 W 081110	488.59	25		8.0	26	NONE	4-51	C431-3	CASING REMOVED
199 B8 4 P	N 067510 W 081420	488.59	25		8.0	26	NONE	4-51	C431-4	CASING REMOVED

Ref. 3.4

WELL DESIGNATION / EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
199 D5 7	N 093520 P W 052140	465.57	35		8.0	36		3-49	107-DR-4	CASING REMOVED
199 D5 8	N 093520 P W 052090	465.57	31		8.0	32		3-49	107-DR-5	CASING REMOVED
199 D5 9	N 093520 P W 051990	462.57	35		8.0	36		3-49	107-DR-6	CASING REMOVED
199 D5 10		464.57	28	DRY	8.0	29	14 - 27	4-57	100-DR-1	
199 D5 11		464.57	27	DRY	8.0	28	14 - 27	4-57	100-DR-2	
199 D5 12 1892	N 092125 P W 052546	469.67	91	85	8.0	91	35 - 90	8-60		SAMPLE PUMP
199 D7 1		420.00	51		48.0	51		0- 0	T14N R26E 14-F1	FILLED IN
199 D7 2		420.00	39		84.0	102		0- 0	T14N R26E 14-F2	FILLED IN
199 D8 1	N 095230 P W 053140	400.00	37		6.0	37		5-43	HR-9	FILLED IN
199 D8 2 1861	N 094725 P W 053018	444.61	77	DRY	8.0	44	30 - 75	6-52	107-D-1	
199 D8 3 1862	N 094720 P W 052205	449.06	81	62	6.0	81	35 - 79	6-52	107-D-2	SAMPLE PUMP

Ref. 3.5

WELL DESIGNATION / EMA NO.	COORDINATES	CASING ELEV. (FT-MSL)	DRILL DEPTH (FT)	INIT. DEPTH (FT) TO WATER	DIA. (IN)	DEPTH TO BOTTOM (FT)	MIN-MAX PERFORATED DEPTH (FT)	DATE COMP. (M-Y)	FORMER DESIGNATION	COMMENTS
199 K 13		464.00	159	72	12.0	138		3-53	100-K	OIL IN WELL
199 K 14		469.05	95		8.0	95		12-52	105-KW-1	
199 K 15	N 077160 P W 069050	408.00	150		6.0	150		4-43	U.S.E.D.TH. NO. 1	
199 K 16	N 076300 P W 067800	404.00	50		8.0	50		2-53	105-KE-1	
199 K 17		406.00	75		8.0	75	50 - 75	9-53	105-KE-2	
199 K 18 1879		409.00	60	21	8.0	40		10-54	107-KE-3	
199 K 19 1884	N 078000 P W 067000	422.17	51	30	8.0	51	10 - 50	4-55	107-KE-4	SCREEN 26-46 FT. SAMPLE PUMP
199 K 20 1885	N 079500 P W 066125	422.57	50	31	8.0	48	10 - 50	5-55	107-KE-5	SAMPLE PUMP
199 K 21 1886	N 080000 P W 066000	421.73	50	DRY	8.0	16	10 - 50	5-55	107-KE-6	
199 K 22 1887	N 081000 P W 065000	421.68	50	30	8.0	49	10 - 50	5-55	107-KE-7	#15 SCREEN 29-49 FT. SAMPLE PUMP
199 K 23	N 078000 P W 068000	405.00	80	DRY	8.0	25	65 - 80	2-56	1706-KER-1	
199 K 24	N 077000 P W 069000	467.00	50		8.0	50	NONE	12-52	105-KW-2	

REFERENCE 4

Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Volume 1, July 1986

2.0 DESCRIPTION OF HANFORD SITE

This section provides a summary of environmental conditions at the Hanford Site and a brief discussion of the Site's purpose and history. It also describes specific environmental features and the the process history of each operational area (i.e., the 100, 200, 300, 400, and 600 Areas).

2.1 ENVIRONMENTAL SUMMARY

The semiarid Hanford Site, operated by the DOE, occupies about 1,476 square kilometers (570 sq mi) of the southeastern part of Washington State north of where the Yakima River flows into the Columbia (see Figure 2.1). The Site lies about 320 kilometers (200 mi) east of Portland, Oregon, 270 kilometers (170 mi) southeast of Seattle, Washington, and 200 kilometers (125 mi) southwest of Spokane, Washington.

Environmental conditions common to all areas at Hanford Site are summarized below. Descriptions of these environmental aspects are based on several recent reports (U.S. DOE 1984; Sommer et al. 1981; Yandon 1977; U.S. ERDA 1975).

2.1.1 Geology and Soils

The Hanford Site lies in the Pasco Basin, a structural and topographic basin of eastern Washington and the Columbia River Basalt Plateau. The region is underlain by three geologic units. In ascending order these are: 1) the sequential beds of basaltic lavas and interbed sediments of the Columbia River Basalt Group at the base; 2) the Pliocene-age Ringold Formation (lacustrine formation), consisting of well-rounded pebbles and cobbles with interstitial spaces filled with medium sand; and 3) the Hanford Formation, consisting of the Pasco (glaciofluvial) gravels and associated sediments of the late Pleistocene age lying at the surface.

The surface geology of the Site is characterized by a surface layer of light brown, fine, slightly silty, wind-deposited sand, sparsely covered by vegetation. Although the surface soil is fertile, it has little agricultural value without irrigation. Underlying the surface sands is a mixture of sand

Ref. 4.1

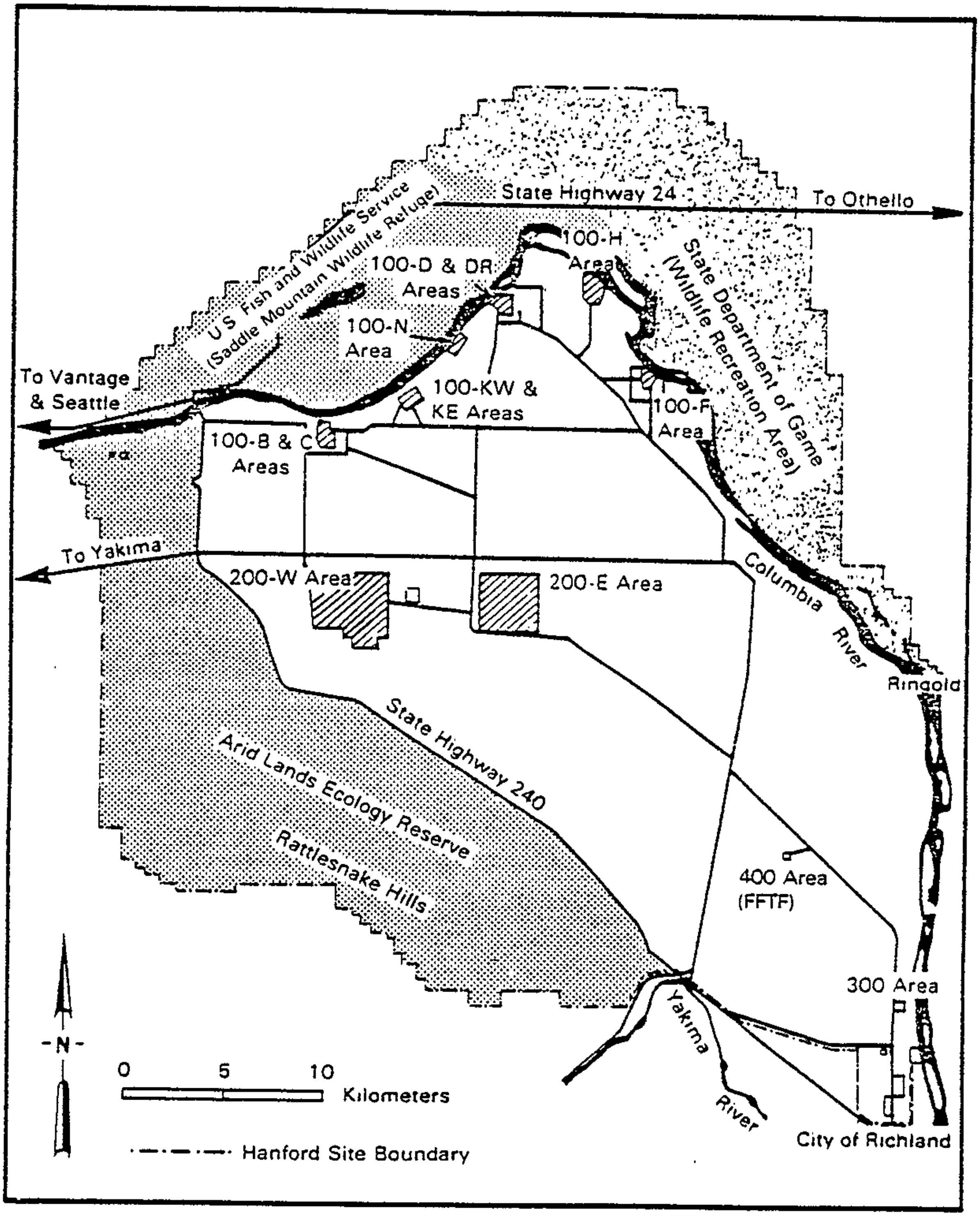

FIGURE 2.1. Features of the Hanford Site.

Ref. 4.2

and gravel extending to a depth of about 60 meters (200 ft). Basaltic rock starts at that depth and extends downward over 3000 meters (1.9 mi).

Elevations range from a low of about 105 meters (345 ft) above mean sea level (MSL) in the southeastern part of the Hanford Site to a maximum of 1,091 meters (3,579 ft) at the crest of Rattlesnake Mountain to the west. (See Section 2.3 for a discussion of geologic features peculiar to each operational area.)

2.1.2 Meteorology

The Site lies east of the Cascade Mountains and, as a result, has a semiarid climate reflecting the rainshadow effect of the mountains. The average annual precipitation for the Site is about 160 millimeters (6.3 in.). Ten percent of this amount falls from July through September, and 42% falls from November through January. The greatest amount of rainfall recorded in a 12-hour period was 47.8 millimeters (1.9 in.).

Because of the limited rainfall, surface runoff from the Hanford Site is minimal. The annual precipitation mostly evaporates, resulting in small amounts of water available for runoff or infiltration.

2.1.3 Hydrology and Hydrogeology

The Columbia River (the fifth largest river by volume in North America) is the dominant aquatic ecosystem on the Hanford Site. Numerous dams have been built on the river. The only free-flowing section in the United States is between Priest Rapids Dam and McNary Reservoir, along the Hanford Site. No significant tributaries enter the stream in this section.

The Columbia has a long-term annual average flow of about 3,600 cubic meters per second (127,000 cfs). [The Yakima River, by comparison, flows an average of about 90 cubic meters per second (3,180 cfs).] The flow rates of the Columbia are influenced by water usage and upstream reservoir projects. The reservoirs provide active storage of more than 4.6×10^{10} cubic meters (37,000,000 acre-feet) of water.

The uppermost aquifer in the Pasco Basin is an unconfined system within the Hanford and Ringold Formations. The elevation of this aquifer ranges from excluded from public use by the DOE and are used as a wildlife refuge and for DOE environmental research. The land north of the Columbia River is controlled by the Washington State Department of Game and the U.S. Fish and Wildlife Service as controlled hunting areas and a game refuge.

Land use within a 50-kilometer (30-mi) radius of the Site includes residential, suburban, corporate city, agricultural, industrial and commercial, scenic, recreational, and general use areas. The predominant use of lands within the 50-kilometer (30-mi) radius is agricultural, with farms located along or near all the Site boundaries.

2.1.6 Population

Population in the area surrounding the Hanford Site is sparse, consisting primarily of farms and farming communities to the north, east, and west of the Site. The Tri-Cities (Kennewick, Pasco, and Richland), located to the south and southeast of the Hanford Site, represent the major population concentration in the area (Sommer et al. 1981).

In 1980, an estimated 341,000 people were living within an 80-kilometer (50-mi) radius of the Hanford Meterological Station (HMS) (see Figure 2.4); it is estimated that the number will grow to 417,000 by 1990.

2.1.7 Air Quality

Air quality in the vicinity of the Hanford Site is generally quite good. Wind-eroded dust is a problem in the area, and the dust storms that occur in the region can produce high total-suspended particulate concentrations. However, on both an annual and a short-term basis, the region is in compliance with the National Ambient Air Quality Standards (NAAQS) for particulates. All other pollutant levels also satisfy the federal and State of Washington standards (U.S. DOE 1984).

2.2 PURPOSE AND HISTORY

In 1943, after the Fermi experiment showed that nuclear fission could be controlled in a small reactor, the U.S. Army Corps of Engineers selected Hanford as the location to build larger versions of the Fermi reactor to produce plutonium for possible use in military weapons. Construction started

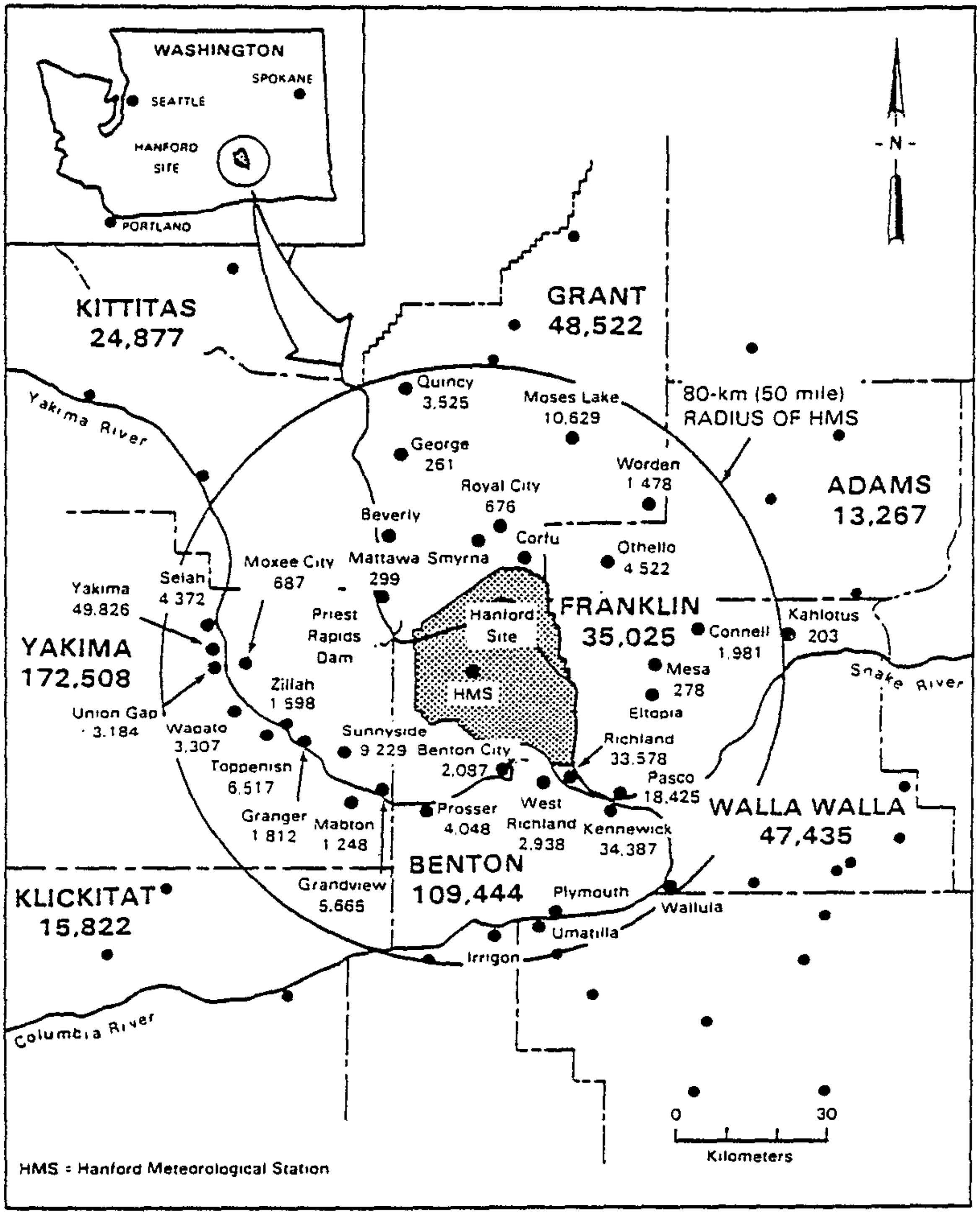

FIGURE 2.4. U.S. Census Populations for 1980 of Cities Within 80 Kilometers of the Hanford Meteorological Station (U.S. DOE 1986)

in March 1943 on three reactor facilities and three chemical processing facilities. The first of the reactors went into operation about 18 months after the start of construction, and the first plutonium was available some 4 months later.

After World War II, five reactors similar to those built during the war were constructed. A total of eight graphite-moderated reactors used the Columbia River for once-through cooling (i.e., water circulated through the reactors only once before being released back to the river).

Early in the 1950s construction began on the research and development facilities known as the Hanford Laboratories. This marked the first diversification of Hanford from a purely defense-materials production facility to one heavily involved in peacetime uses of the atom.

In 1963 the N Reactor was built. The N Reactor is different from the other eight reactors in that it generates steam as a by-product of the plutonium production and does not use river water as a once-through coolant. Since 1966 the Washington Public Power Supply System has used the steam to generate electricity.

A presidential decision was made in early 1964 to begin shutting down the older Hanford reactors. This decision resulted in the closing down of all eight of the older reactors by the end of 1971, leaving the N Reactor as the only operational production reactor.

2.3 DESCRIPTION OF OPERATIONAL AREAS

Environmental features specific to each operational area are described below; the waste-processing history of each area is also discussed. Each area is identified by number (i.e., 100, 200, 300, 400, and 600) and by letter (e.g., the 100-F Area is the location of the 100-Area F Reactor). Appendix B provides further information on waste-disposal site locations and types of waste-processing facilities in Hanford's operational areas.

2.3.1 100 Areas

The nine 100 Areas (B, C, D, DR, KE, KW, F, H, N) border the Columbia River in the northernmost part of the Hanford Site. Each of the nine areas has one production reactor. Eight of these reactors have been shut down; only the N Reactor, used for both plutonium and electricity production, is still operating. Because some of the areas are contiguous (B/C, D/DR, KE/KW), the Hanford Site map shows only six 100 Areas (Figure 2.1).

The 100 Areas are generally flat with no major surface features. The Hanford Formation lies near the surface of the 100 Areas, covered by a thin layer of wind-deposited silt and fine sand. The water table is found in these sediments at a depth of about 20 meters (66 ft), except in the F and H Areas where the depth to the water table is about 35 meters (115 ft) and 40 meters (131 ft), respectively. The depth to the Ringold Formation is about 25 meters (82 ft); the top of the basalt bedrock is approximately 240 meters (790 ft) below the surface.

Because the water table occurs within the highly permeable sandy gravels of the Hanford Formation, it fluctuates as the river level rises and falls. The ground water generally flows from the 100 Areas and toward the river. When active, each of the 100 Areas included support facilities such as powerhouses. Except for 100-N, these powerhouses produced process steam from coal-fired boilers; 100-N has oil-fired boilers. Adjacent to each area's powerhouse were large storage areas that received railroad carloads of coal and disposal areas for flyash/clinker disposal. Most areas also included water-treatment plants, water-storage tanks, subsurface sewage-disposal systems, raw-water intake structures, and process sewers.

B and C Areas. The B and C reactors are located adjacent to each other on a 2.6-square-kilometer (650-acre) site (the 100 B/C Area) and are the farthest upstream of the 100 Areas. The B Reactor was operated from 1944 to 1968, and the C Reactor was operated from 1952 to 1969. Virtually all the facilities in the area are inactive, with the exception of the B/C export water system, which continues to provide the raw water supply to the 200 Area and some 100 Areas. An electrical substation in the area taps power for the pumps providing the 200-Area water. Fewer than 100 people work in this area (Yandon 1977).

When the reactors were operational, cooling water was drawn from the river and treated with alum, sulfuric acid, and chlorine. Excess sulfuric

Ref. 4.7

acid was used to maintain the pH of the water within a desired range. To control oxidation of aluminum parts in the reactor, sodium dichromate was used to maintain an oxidation coating on aluminum parts. The chlorine was added for algae control in the settling basins; at times copper sulfate was added for additional algae control. Chromic acid, oxalic acid, and nitric acid were used for dummy fuel-element decontamination.

In addition to vertical safety rods for emergency reactor shutdown, the reactors were equipped with hoppers of nickel-plated boron steel balls, nickel-plated carbon steel balls, and stainless steel balls that would drop into the vertical safety rod channels for emergency shutdown. This system required no supplementary power source. Although it was never used, a third safety system, one involving the use of a potassium borate solution, was in place at the reactors.

A supplementary control system, in addition to the normal horizontal control rods, was incorporated into the reactors. This supplementary control system consisted of a Poison[a] Column Control Facility that could charge selected process tubes with a lead-cadmium poison to absorb neutrons. Boron-carbide aluminum poison splines were also used for supplementary control.

The coolant water system and backup control and shutdown systems at the other 7 once-through-cooled reactors were similar to the those in 100 B/C Area.

<u>D and DR Areas</u>. The 100-D/DR Areas, covering about 3.9 square kilometers (970 acres), are located 11 kilometers (7 mi) downriver of the 100-B/C Area. The D Reactor was operated from 1944 to 1967 and the DR Reactor from 1950 to 1965. These areas are extensively used, and their utilities and services are still in operation. The electrical substation serves as a backup supply for the 100-N Area. The water system is a backup system for the 100-B water system, which supplies water to the 200 Areas. The UNC Nuclear Industries engineering laboratory here is operated in support of the N Reactor. Approximately 20 people are employed in the D and DR Areas (Yandon 1977).

(a) The term poison refers to a material's ability to absorb neutrons and thus control the rate of fission.

Ref. 4.8

Ref. 4.9

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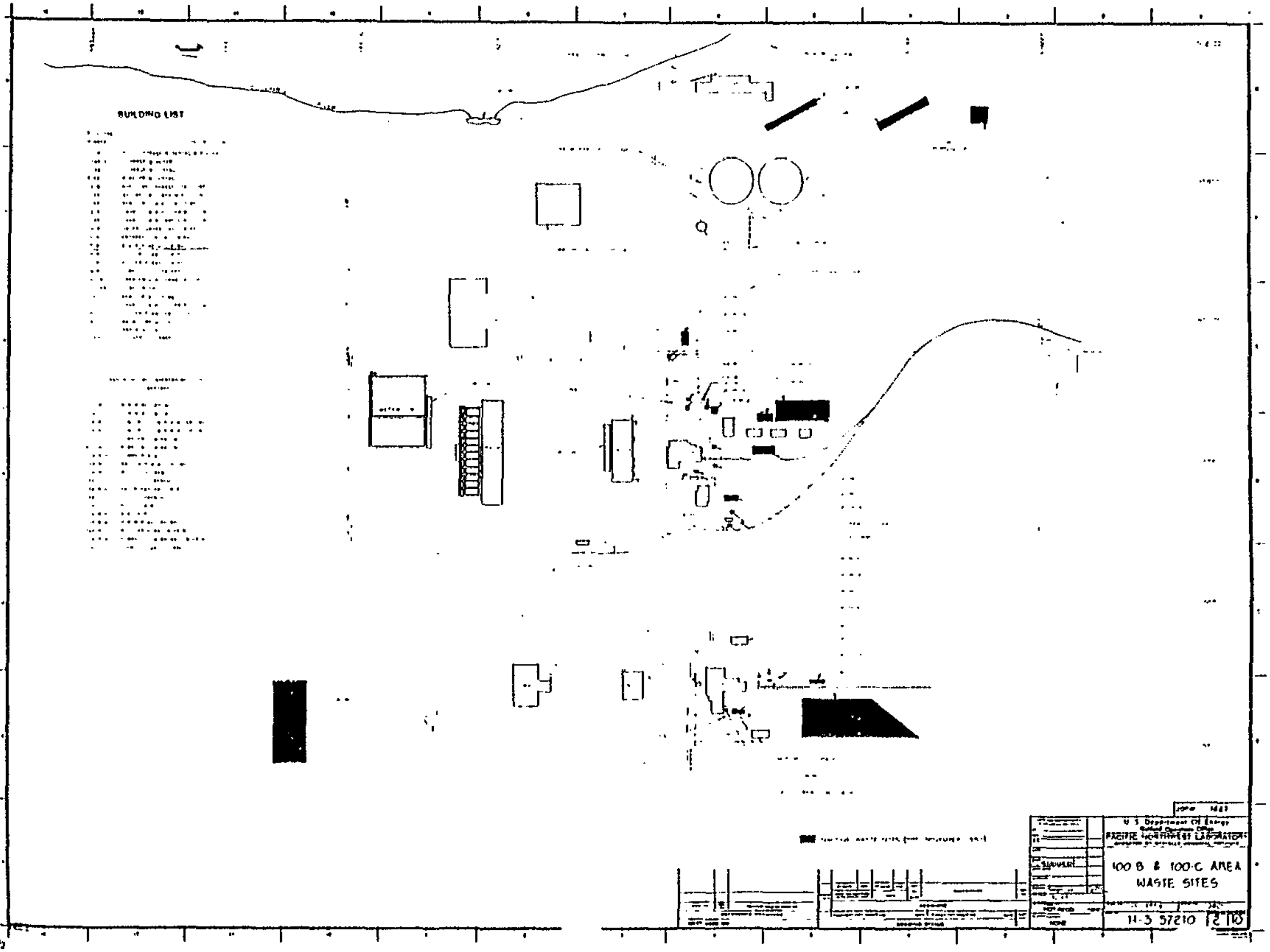

0 4 0 1 0 6 8 1 1 1 6

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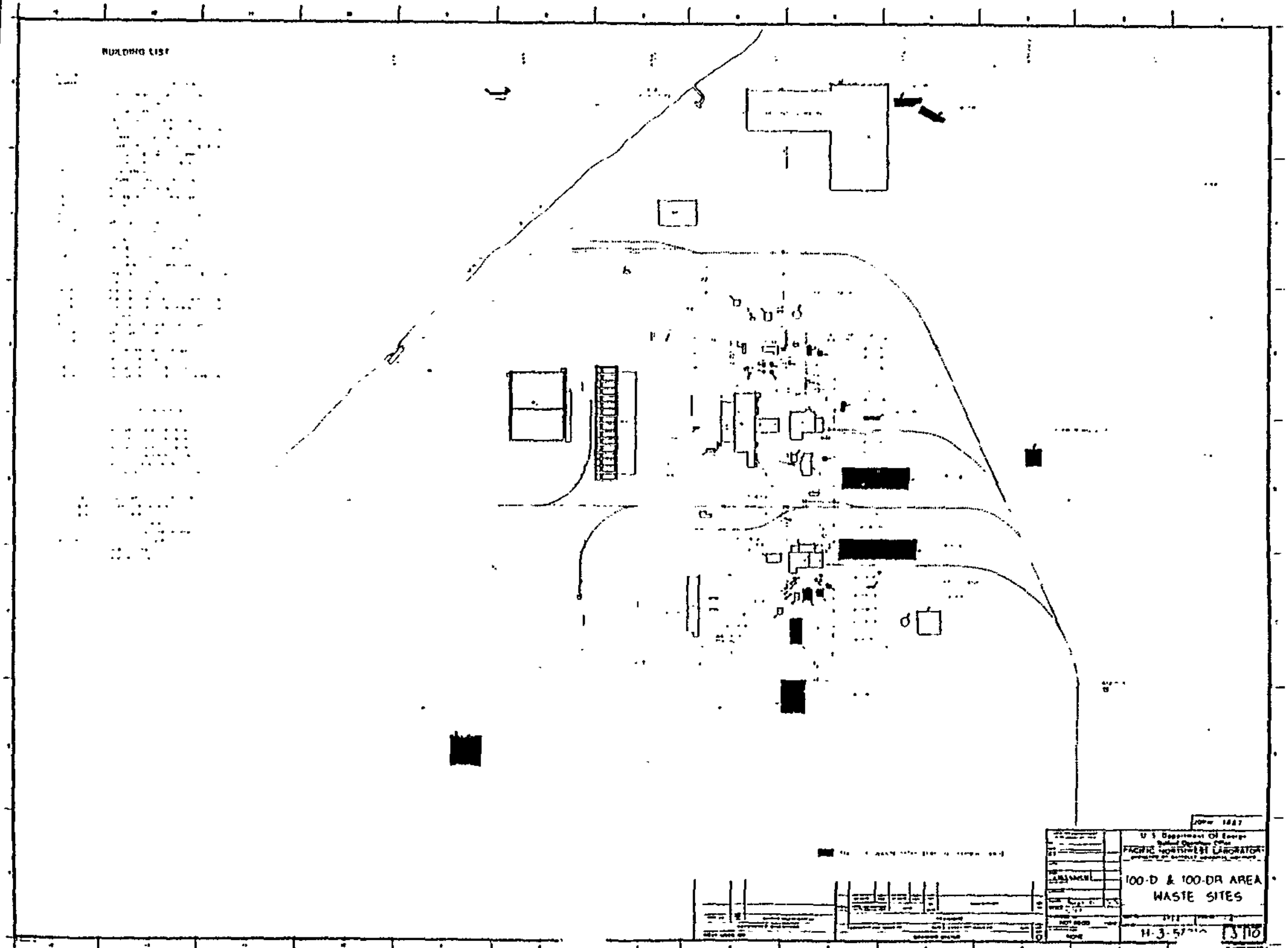

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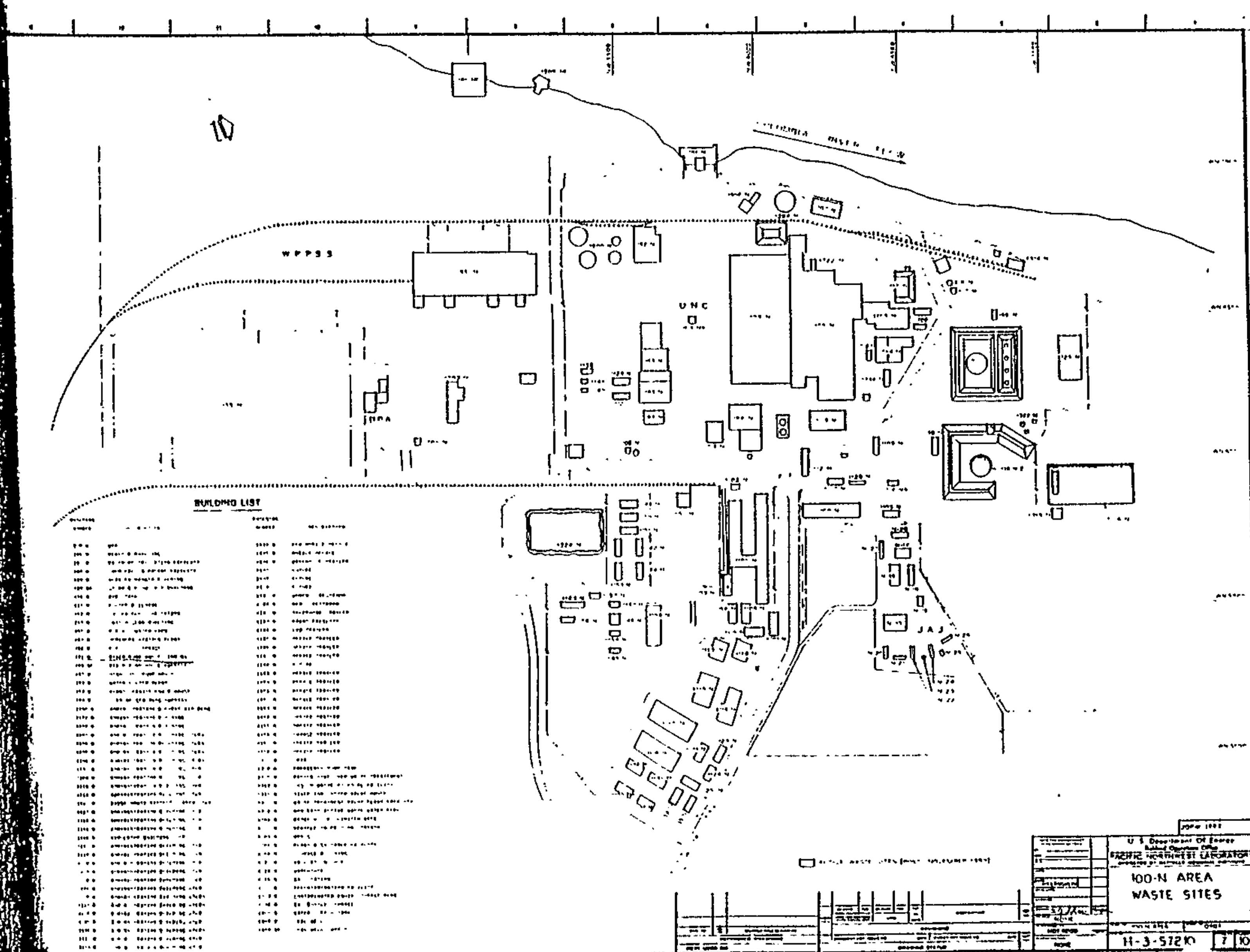

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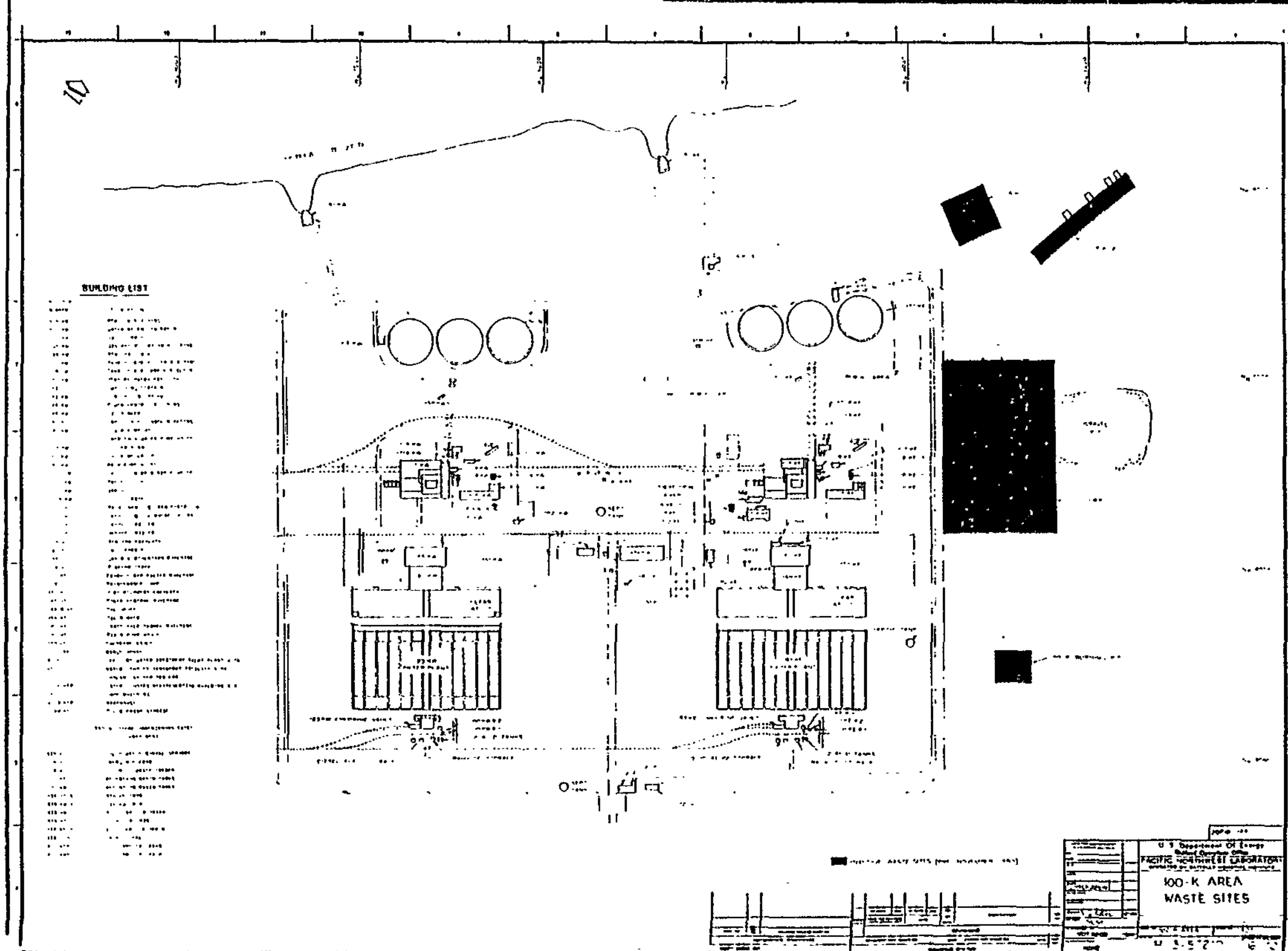

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REFERENCE 5

Environmental Monitoring at Hanford for 1986, PNL-6120, May 1987

2.0. BACKGROUND INFORMATION

2.1. DESCRIPTION OF THE HANFORD SITE

K. R. Price, P. J. Mitchell, and M. D. Freshley

The U.S. Department of Energy's Hanford Site is located in a rural region of southeastern Washington and occupies an area of 1,500 km^2. The Site (shown in Figure 2.1) lies about 320 km northeast of Portland, Oregon, 270 km southeast of Seattle, Washington, and 200 km southwest of Spokane, Washington. The Columbia River flows through the northern edge of the Hanford Site and forms part of the eastern boundary. The southern boundary of the Site includes the Rattlesnake Hills, which exceed 1000 m in elevation. Both confined and unconfined aquifers are present beneath the Site. The main geologic units are the Columbia River Basalt Group, the Ringold Formation, and a series of glaciofluvial sediments. The Hanford Project was established in 1943 and was originally designed, built, and operated to produce plutonium for nuclear weapons.

SURFACE CHARACTERISTICS OF THE SITE

The semiarid land on which the Hanford Site is located has a sparse covering of desert shrubs and drought-resistant grasses. The most broadly distributed type of vegetation on the Site is the sagebrush/cheatgrass/bluegrass community. Most abundant of the mammals is the Great Basin pocket mouse. Of the big-game animals, the mule deer is the most abundant, while the cottontail rabbit is the most abundant of the small-game animals. Coyotes are also abundant. The bald eagle is a regular winter visitor to the relatively large areas of uninhabited land comprising the Hanford Site.

The Columbia River, which originates in the mountains of eastern British Columbia, Canada, flows through the northern edge of the Hanford Site and forms part of the Hanford Site's eastern boundary. The river drains a total area of approximately 70,800 km^2 enroute to the Pacific Ocean. The flow of the Columbia River is regulated by 11 dams within the United States, 7 upstream and 4 downstream of the Site. Priest Rapids Dam is the nearest impoundment upstream of the Site, and McNary Dam is the nearest dam downstream. (The Hanford reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula, which is created by McNary Dam.) This is the only stretch of the Columbia River within the U.S. that is not impounded by a dam. The width of the river varies from approximately 300 m to about 1000 m. The flow through this stretch of the river is relatively swift, with numerous bends and several islands present throughout the reach.

The flow rate of the Columbia River in this region is regulated primarily by Priest Rapids Dam. Hanford reach flows fluctuate significantly because of the relatively small storage capacity and operational practices of the nearby upstream dams. A minimum flow rate of 1,000 cubic meters per second (m^3/s) [36,000 cubic feet per second (cfs)] has been established at Priest Rapids. Typical daily flows range from 1,000 m^3/s (36,000 cfs) to 7,000 m^3/s (250,000 cfs) with peak spring runoff flows of up to 12,600 m^3/s (450,000 cfs) being recorded. Typical annual average flows at Priest Rapids Dam are 3,100 m^3/s (110,000 cfs) to 3,400 m^3/s (120,000 cfs). Monthly mean flows typically peak from April through June and are at the lowest levels from September through October.

The temperature of the Columbia River varies seasonally. Minimum temperatures are observed during January and February while maximum temperatures typically occur during August and September. Monthly temperatures for the river range from approximately 3°C to about 20°C during the course of a year. Water storage management practices at upstream dams and the flow rate of the river dictate, to a large extent, the thermal characteristics of the Columbia River along the Hanford reach.

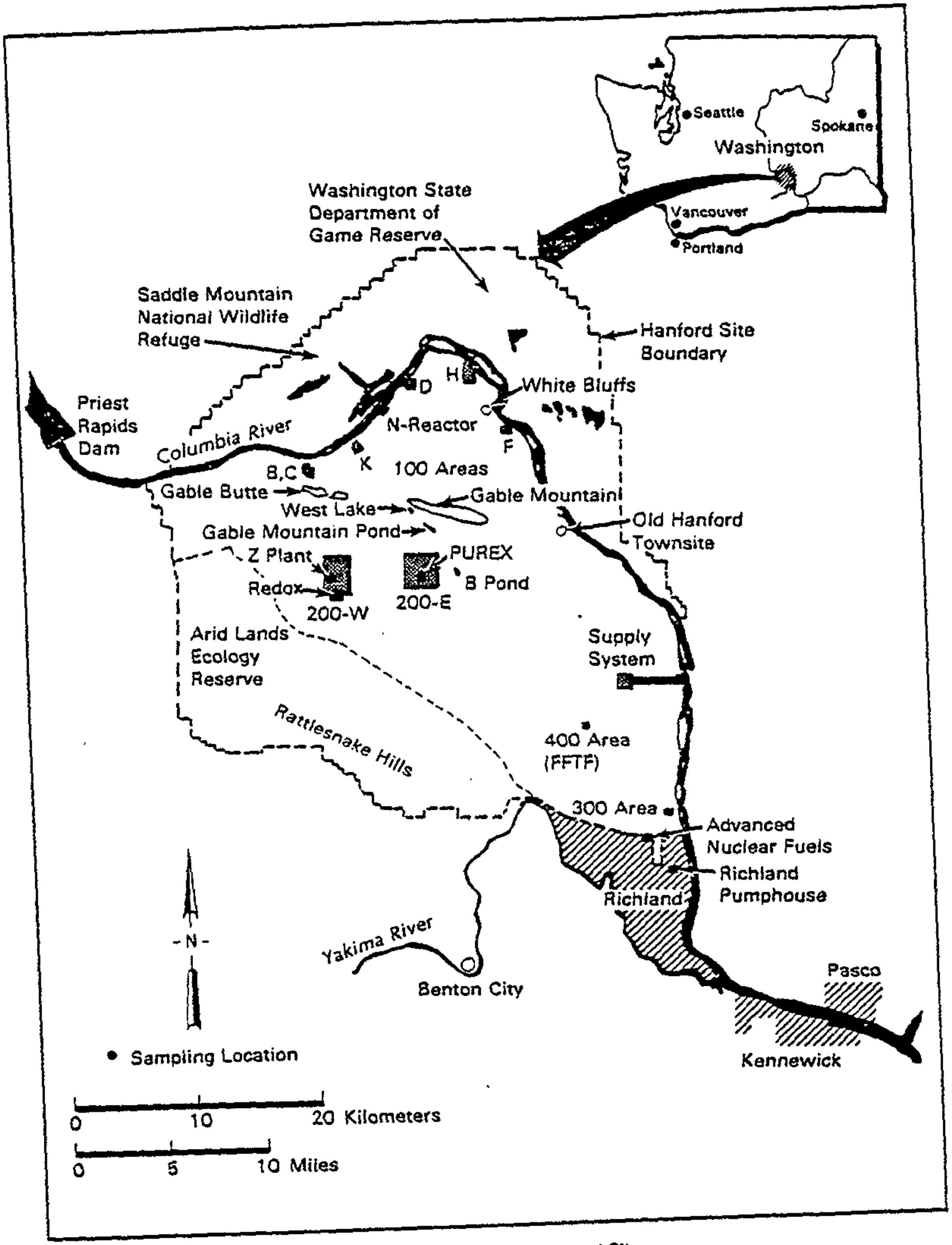


FIGURE 2.1. DOE's Hanford Site

Ref. 5.2

The Columbia River system has been developed extensively for hydroelectric power, flood control, navigation, irrigation, and municipal and industrial water supplies. In addition, the Hanford reach is used for a variety of recreational activities including fishing, hunting, boating, water skiing, and swimming. The State of Washington has classified the stretch of the Columbia River from the Washington-Oregon border to Grand Coulee Dam (which includes the Hanford reach) as Class A and established water quality criteria and water use guidelines for this class designation. Because these criteria do not include specific limits for radionuclides, Environmental Protection Agency (EPA) and State of Washington drinking water limits were used for comparison. Other surface water on the Site consists of West Lake (a small, natural pond) and a number of ditches and artificial ponds created for routine disposal of waste water.

Hanford's climate is dry and mild; the area receives approximately 16 cm of precipitation annually. About 40% of the total precipitation occurs during November, December, and January; only 10% falls in July, August, and September. Approximately 45% of all precipitation from December through February is snow. The average minimum and maximum temperatures in July are 16°C and 32°C. For January, the average temperatures are 3°C and -6°C.

Monthly average wind speeds range from about 10 km/h in the summer to 14 km/h in the winter. The prevailing regional winds are from the northwest, with occasional cold-air drainage into valleys and occurrences of strong crosswinds. The region is a typical desert area with frequent strong inversions that occur at night and break during the day, resulting in unstable and turbulent wind conditions.

Land near the Hanford Site is primarily used for agriculture and for livestock grazing. Agricultural lands are found north and east of the Columbia River and south of the Yakima River. These areas contain orchards, vineyards, and fields of alfalfa, wheat, and vegetables. The Hanford Site north of the Columbia River is shared between a state wildlife management area and a federal wildlife refuge. The northeast slope of the Rattlesnake Hills along the southwestern boundary of the Site is designated as the Arid Lands Ecology Reserve (ALE) and is used for ecological research by DOE.

The major population center nearest to the Hanford Site is the Tri-Cities area (Richland, Pasco, and Kennewick), which is situated on the Columbia River downstream from the Site and has a population of approximately 90,000. Approximately 340,000 people live within an 80-km radius of the Hanford Site. This number includes people living in the Tri-Cities, the Yakima area, several small communities, and the surrounding agricultural area. More detail on Site characteristics and activities is available in "The Final Environmental Statement, Waste Management Operations, Hanford Reservation" (ERDA 1975).

SUBSURFACE CHARACTERISTICS OF THE SITE

The DOE operations on the Site have resulted in the production of large volumes of waste water that have historically been discharged to the ground through cribs, ditches, and ponds. These discharges greatly influence the physics and chemistry of the subsurface. Approximately 25 billion liters of liquid effluent in the 200 Areas and 2.6 billion liters of liquid effluent in the 100N Area were disposed to the ground during 1986, including process cooling water and water containing low-level radioactive wastes. The discharge of waste water to the ground at the Hanford Site began in the mid-forties and reached a peak in 1955. After 1955, discharge to cribs declined because of improved treatment of waste streams and the deactivation of various facilities (Graham et al. 1981). Since the restart of the Plutonium and Uranium Extraction (PUREX) Plant and related facilities in late 1983, discharge of PUREX-related effluents has resumed.

Subsurface structures, such as cribs, have primarily been used for the disposal of water containing radioactive wastes, while surface ponds and ditches have primarily been used for the disposal of uncontaminated cooling water (Graham et al. 1981). Sanitary wastes are discharged to the ground via tile fields. The majority of liquid disposal occurred in the Separations Area, which includes the 200-East (200E) and 200-West (200W) Areas (Figure 2.1). Smaller amounts of waste water were disposed in the 100 and 300 Areas. Discharges of waste water to the ground in the 400 Area were minimal.

Ref. 5.3

the Ringold formation has been removed. These sediments were deposited by the ancestral Columbia River when it was swollen by glacial meltwater. The glaciofluvial sediments consist primarily of gravels and sands, with some silts (Newcomb, Strand and Frank 1972).

Hydrology

Both confined and unconfined aquifers are present beneath the Hanford Site. The confined aquifers, in which the ground water is under pressure greater than that of the atmosphere, are found primarily within the Columbia River basalts. In general, the unconfined or water-table aquifer is located in the Ringold Formation and glaciofluvial sediments, as well as some more recent alluvial sediments in areas adjacent to the Columbia River (Gephart et al. 1979). This relatively shallow aquifer has been affected by waste-water disposal at Hanford more than the confined aquifers (Graham et al. 1981). Therefore, the unconfined aquifer is the most thoroughly monitored aquifer beneath the Site.

The unconfined aquifer is bounded below by either the basalt surface or, in places, the relatively impervious clays and silts of the lower unit of the Ringold Formation. Laterally, the unconfined aquifer is bounded by the anticlinal basalt ridges that ring the basin and by the Yakima and Columbia rivers. The basalt ridges above the water table have a low permeability and act as a barrier to lateral flow of the ground water (Gephart et al. 1979). The saturated thickness of the unconfined aquifer is greater than 61 m in some areas of the Hanford Site and pinches out along the flanks of the basalt anticlines. The depth from the ground surface to the water table ranges from less than 0.3 m near the Columbia River to over 106 m in the center of the Site. The elevation of the water table above mean sea level for June of 1986 is shown in Figure 2.3.

Recharge to the unconfined aquifer originates from several sources (Graham et al. 1981). Natural recharge occurs from precipitation at higher elevations and runoff from ephemeral streams to the west, such as Cold Creek and Dry Creek. The Yakima River recharges the unconfined aquifer as it flows along the southwest boundary of the Hanford Site. The Columbia River recharges the unconfined aquifer during high stages when river water is transferred to the aquifer along the river bank. The unconfined aquifer receives little, if any, recharge from precipitation directly on the Hanford Site because of a high rate of evapotranspiration under native soil and vegetation conditions. However, present studies, such as those described by Heller, Gee, and Meyers (1985), suggest that precipitation may contribute more recharge to the ground water than was originally thought.

Large scale artificial recharge occurs from offsite agricultural irrigation and liquid-waste disposal in the operating areas at Hanford. Recharge from irrigation in the Cold Creek Valley enters the Hanford Site as ground-water flow across the western boundary. Artificial recharge from waste-water disposal at Hanford occurs principally in the Separations Area. It was estimated that recharge to the ground water from facilities in the Separations Area (including B Pond and Gable Mountain Pond, as well as the various cribs and trenches in the 200W and 200E Areas) adds ten times as great an annual volume of water to the unconfined aquifer as is contributed by natural inflow to the area from precipitation and irrigation waters to the west (Graham et al. 1981).

The operational discharge of water has created ground-water mounds near each of the major waste-water disposal facilities in the Separations Area and in the 100 and 300 Areas (Figure 2.3). These mounds have altered the local flow pattern in the aquifer, which is generally from the recharge areas in the west to the discharge areas (primarily the Columbia River) in the east. Water levels in the unconfined aquifer have changed continuously during Site operations because of variations in the volume of waste water discharged. Consequently, the movement of ground water and its associated constituents has also changed with time.

In addition to the Separations Area, ground-water mounding also occurs in the 100 and 300 Areas. Ground-water mounding in these areas is not as significant as in the Separations Area because of differences in discharge volumes and subsurface geology. However, in the 100 and 300 Areas, water levels are also greatly influenced by river stage.

Liquid Effluent Movement

If significant quantities of liquid effluents are discharged to the ground at the Hanford Site waste disposal facilities, then these effluents would percolate downward through the unsaturated zone to the water table. As

100 Area Background and Down Gradient Wells

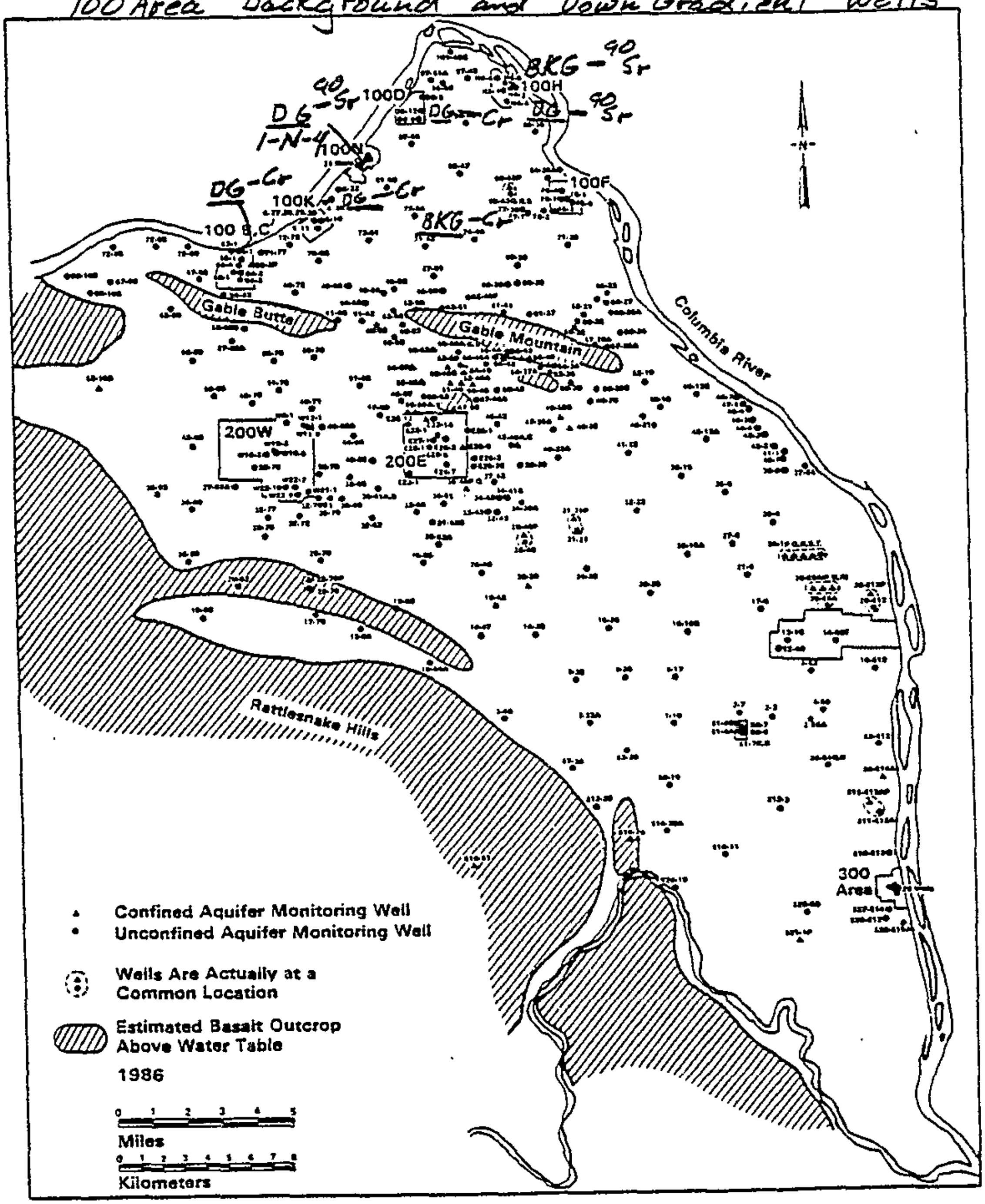


FIGURE 3.10. Location of Ground-Water Monitoring Wells Sampled in 1986 (first digit of well number has been dropped)

Ref. 5.5

REFERENCE 6

Draft Phase I Installation Assessment of Inactive Waste-Disposal Site at Hanford, Volume 2, July 1986

NOTE: This site contains numerous sheets from the document; reference is made to the document instead of attaching all of the individual sheets.

REFERENCE 7

Uncontrolled Hazardous Waste Site Ranking System; A Users Manual,

40 CFR 300, Appendix A

Physical state refers to the state of the hazardous substances at the time of disposal, except that gases generated by the hazardous substances in a disposal area should be considered in rating this factor. Each of the hazardous substances being evaluated is assigned a value as follows:

Physical state	Assigned value
Solid, consolidated or stabilized	0
Solid, unconsolidated or unstabilized	1
Powder or fine material	2
Liquid, sludge or gas	3

3.3 *Containment*

Containment is a measure of the natural or artificial means that have been used to minimize or prevent a contaminant from entering ground water. Examples include liners, leachate collection systems, and sealed containers. In assigning a value to this rating factor (Table 3), consider all ways in which hazardous substances are stored or disposed at the facility. If the facility involves more than one method of storage or disposal, assign the highest from among all applicable values (e.g., if a landfill has a containment value of 1, and, at the same location, a surface impoundment has a value of 2, assign containment a value of 2).

TABLE 3—CONTAINMENT VALUE FOR GROUND WATER ROUTE

Assign containment a value of 0 if: (1) All the hazardous substances at the facility are underlain by an essentially non permeable surface (natural or artificial) and adequate leachate collection systems and diversion systems are present; or (2) there is no ground water in the vicinity. The value "0" does not indicate no risk. Rather, it indicates a significantly lower relative risk when compared with more serious sites on a national level. Otherwise, evaluate the containment for each of the different means of storage or disposal at the facility, using the following guidance.

	Assigned value
A. Surface Impoundment	
Sound run-on diversion structure, essentially non permeable liner (natural or artificial) compatible with the waste, and adequate leachate collection system	0
Essentially non permeable compatible liner with no leachate collection system; or inadequate freeboard	1
Potentially unsound run-on diversion structure, or moderately permeable compatible liner	2
Unsound run-on diversion structure, no liner, or incompatible liner	3
B. Containers	
Containers sealed and in sound condition, adequate liner, and adequate leachate collection system	0

TABLE 3—CONTAINMENT VALUE FOR GROUND WATER ROUTE—Continued

Assign containment a value of 0 if: (1) All the hazardous substances at the facility are underlain by an essentially non permeable surface (natural or artificial) and adequate leachate collection systems and diversion systems are present; or (2) there is no ground water in the vicinity. The value "0" does not indicate no risk. Rather, it indicates a significantly lower relative risk when compared with more serious sites on a national level. Otherwise, evaluate the containment for each of the different means of storage or disposal at the facility, using the following guidance.

	Assigned value
Containers sealed and in sound condition, no liner or moderately permeable liner	1
Containers leaking, moderately permeable liner	2
Containers leaking and no liner or incompatible liner	3
C. Piles	
Piles uncovered and waste stabilized; or piles covered, waste unstabilized, and essentially non permeable liner	0
Piles uncovered, waste unstabilized, moderately permeable liner, and leachate collection system	1
Piles uncovered, waste unstabilized, moderately permeable liner, and no leachate collection system	2
Piles uncovered, waste unstabilized, and no liner	3
D. Landfill	
Essentially non permeable liner, liner compatible with waste, and adequate leachate collection system	0
Essentially non permeable compatible liner, no leachate collection system, and landfill surface precludes ponding	1
Moderately permeable, compatible liner, and landfill surface precludes ponding	2
No liner or incompatible liner; moderately permeable compatible liner; landfill surface encourages ponding; no run-on control	3

3.4 *Waste Characteristics.* In determining a waste characteristics score, evaluate the most hazardous substances at the facility that could migrate (i.e., if scored, containment is not equal to zero) to ground water. Take the substance with the highest score as representative of the potential hazard due to waste characteristics. Note that the substance that may have been observed in the release category can differ from the substance used in rating waste characteristics. Where the total inventory of substances in a facility is known, only those present in amounts greater than the reportable quantity (see CERCLA section 102 for definition) may be evaluated.

Toxicity and Persistence have been combined in the matrix below because of their important relationship. To determine the overall value for this combined factor, evaluate each factor individually as discussed below. Match the individual values assigned with the values in the matrix for the combined rating factor. Evaluate several of the most hazardous substances at the facility independently and enter only the highest score in the matrix on the work sheet.

Value for toxicity	Value for persistence: 0	1	2	3
0	0	0	0	0
1	3	6	9	12
2	6	9	12	15
3	9	12	15	18

Persistence of each hazardous substance is evaluated on its biodegradability as follows:

Substance	Assigned value
Easily biodegradable compounds	0
Straight chain hydrocarbons	1
Substituted and other ring compounds	2
Metals, polycyclic compounds and halogenated hydrocarbons	3

More specific information is given in Tables 4 and 5.

TABLE 4—WASTE CHARACTERISTICS VALUES FOR SOME COMMON CHEMICALS

Chemical/Compound	Toxicity[1]	Persistence[2]	Ignitability[3]	Reactivity[4]
Acetaldehyde	3	0	3	2
Acetic Acid	3	0	2	1
Acetone	2	0	3	0
Aldrin	3	3	1	0
Ammonia, Anhydrous	3	0	1	0
Aniline	3	1	2	0
Benzene	3	1	3	0
Carbon Tetrachloride	3	3	0	0
Chlordane	3	3	*0	*0
Chlorobenzene	2	2	3	0
Chloroform	3	3	0	0
Cresol-O	3	1	2	0
Cresol-M&P	3	1	1	0
Cyclohexane	2	2	3	0
Endrin	3	3	1	0
Ethyl Benzene	2	1	3	0
Formaldehyde	3	0	2	0
Formic Acid	3	0	2	0
Hydrochloric Acid	3	0	0	0
Isopropyl Ether	3	1	3	1
Lindane	3	3	1	0
Methane	1	1	3	0
Methyl Ethyl Ketone	2	0	3	0
Methyl Parathion in Xylene Solution	3	Δ0	3	2
Naphthalene	2	1	2	0
Nitric Acid	3	0	0	0
Parathion	3	Δ0	1	2
PCB	3	3	Δ0	Δ0
Petroleum, Kerosene (Fuel Oil No. 1)	3	1	2	0
Phenol	3	1	2	0

TABLE 4—WASTE CHARACTERISTICS VALUES FOR SOME COMMON CHEMICALS—Continued

Chemical/Compound	Toxicity[1]	Persistence[2]	Ignitability[3]	Reactivity[4]
Sulfuric Acid	3	0	0	2
Toluene	2	1	3	0
Trichlorobenzene	2	3	1	0
1,1,1-Trichloroethane	2	2	1	0
Xylene	2	1	3	0

[1] Sax, N. I., *Dangerous Properties of Industrial Materials*, Van Nostrand Reinhold Co., New York, 4th ed., 1975. The highest rating listed under each chemical is used.

[2] JRB Associates, Inc., *Methodology for Rating the Hazard Potential of Waste Disposal Sites*, May 5, 1980.

[3] National Fire Protection Association, National Fire Codes, Vol. 13, No. 49, 1977.

[4] Professional judgment based on information contained in the U.S. Coast Guard CHRIS Hazardous Chemical Data, 1978.

Δ Professional judgment based on existing literature.

TABLE 5—PERSISTENCE (BIODEGRADABILITY) OF SOME ORGANIC COMPOUNDS*

Value=3 Highly Persistent Compounds	
aldrin	heptachlor
benzopyrene	heptachlor epoxide
benzothiazole	1,2,3,4,5,7,7-heptachloronorbornene
benzothiophene	hexachlorobenzene
benzyl butyl phthalate	hexachloro-1,3-butadiene
bromochlorobenzene	hexachlorocyclohexane
bromoform butanal	hexachloroethane
bromophenyl phenyl ether	methyl benzothiazole
chlordane	pentachlorobiphenyl
chlorohydroxy benzophenone	pentachlorophenol
bis-chloroisopropyl ether	1,1,3,3-tetrachloroacetone
m-chloronitrobenzene	tetrachlorophenyl
DDE	thiomethylbenzothiazole
DDT	trichlorobenzene
dibromobenzene	trichlorobiphenyl
dibutyl phthalate	trichlorofluoromethane
1,4-dichlorobenzene	2,4,6-trichlorophenol
dichlorodifluoroethane	triphenyl phosphate
dieldrin	bromodichloromethane
diethyl phthalate	bromoform
di(2-ethylhexyl)phthalate	carbon tetrachloride
dihexyl phthalate	chloroform
di-isobutyl phthalate	chlorodibromomethane
dimethyl phthalate	dibromodichloroethane
4,6-dinitro-2-aminophenol	tetrachloroethane
dipropyl phthalate	1,1,2-trichloroethane
endrin	
Value=2 Persistent Compounds	
acenaphthylene	cis-2-ethyl-4-methyl-1,3-dioxolane
atrazine	trans-2-ethyl-4-methyl-1,3-dioxolane
(diethyl) atrazine	guaiacol
barbital	2-hydroxyadiponitrile
borneol	isophorone
bromobenzene	indene
camphor	isoborneol
chlorobenzene	isopropenyl-4-isopropyl benzene
1,2-bis-chloroethoxy ethane	2-methoxy biphenyl
b-chloroethyl methyl ether	methyl biphenyl
chloromethyl ether	methyl chloride

TABLE 5—PERSISTENCE (BIODEGRADABILITY) OF SOME ORGANIC COMPOUNDS*—Continued

chloromethyl ethyl ether	methylindene
3 chloropyridine	methylene chloride
di t butyl p benzoquinone	nitroanisole
dichloroethyl ether	nitrobenzene
dihydrocarvone	1,1,2 trichloroethylene
dimethyl sulfoxide	trimethyl trioxo-hexahydro-triazine isomer
2,6 dinitrotoluene	
Value=1 Somewhat Persistent Compounds	
acetylene dichloride	limonene
behenic acid, methyl ester	methyl ester of lignoceric acid
benzene	methane
benzene sulfonic acid	2 methyl 5-ethyl pyridine
butyl benzene	methyl naphthalene
butyl bromide	methyl palmitate
e-caprolactam	methyl phenyl carbinol
carbon-disulfide	methyl stearate
o-cresol	naphthalene
decane	nonane
1,2-dichloroethane	octane
1,2 dimethoxy benzene	octyl chloride
1,3 dimethyl naphthalene	pentane
1,4-dimethyl phenol	phenyl benzoate
dioctyl adipate	phthalic anhydride
n-decane	propylbenzene
ethyl benzene	1 terpineol
2-ethyl n-hexane	toluene
o-ethyltoluene	vinyl benzene
isodecane	xylene
isopropyl benzene	
Value=0 Nonpersistent Compounds	
acetaldehyde	methyl benzoate
acetic acid	3-methyl butanol
acetone	methyl ethyl ketone
acetophenone	2 methylpropanol
benzoic acid	octadecane
di-isobutyl carbinol	pentadecane
docosane	pentanol
eicosane	propanol
ethanol	propylamine
ethylamine	tetradecane
hexadecane	n-tridecane
methanol	n-undecane

* JRB Associates, Inc., *Methodology for Rating the Hazard Potential for Waste Disposal Sites*, May 5, 1980

Toxicity of each hazardous substance being evaluated is given a value using the rating scheme of Sax (Table 6) or the National Fire Protection Association (NFPA) (Table 7) and the following guidance:

Toxicity	Assigned value
Sax level 0 or NFPA level 0	0
Sax level 1 or NFPA level 1	1
Sax level 2 or NFPA level 2	2
Sax level 3 or NFPA level 3 or 4	3

TABLE 6—SAX TOXICITY RATINGS

0–No Toxicity* (None)**

The designation is given to materials which fall into one of the following categories
(a) Materials which cause no harm under any conditions of normal use
(b) Materials which produce toxic effects on humans only under the most unusual conditions or by overwhelming dosage

1–Slight Toxicity* (Low)**

(a) *Acute local.* Materials which on single exposures lasting seconds, minutes, or hours cause only slight effects on the skin or mucous membranes regardless of the extent of the exposure
(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slight effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose regardless of the quantity absorbed or the extent of exposure
(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years cause only slight and usually reversible harm to the skin or mucous membranes. The extent of exposure may be great or small
(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slightly usually reversible effects extending over days, months, or years. The extent of the exposure may be great or small

In general, those substances classified as having "slight toxicity" produce changes in the human body which are readily reversible and which will disappear following termination of exposure, either with or without medical treatment.

2–Moderate Toxicity* (Mod)**

(a) *Acute local.* Materials which on single exposure lasting seconds, minutes, or hours cause moderate effects on the skin or mucous membranes. These effects may be the result of intense exposure for a matter of seconds or moderate exposure for a matter of hours
(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and produce moderate effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose

TABLE 6—SAX TOXICITY RATINGS—Continued

2–Moderate Toxicity* (Mod)**

(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years cause moderate harm to the skin or mucous membranes
(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce moderate effects following continuous or repeated exposures extending over periods of days, months or years

Those substances classified as having "moderate toxicity" may produce irreversible as well as reversible changes in the human body. These changes are not of such severity as to threaten life or to produce serious physical impairment.

3–Severe Toxicity* (High)**

(a) *Acute local.* Materials which on single exposure lasting seconds or minutes cause injury to skin or mucous membranes of sufficient severity to threaten life or to cause permanent physical impairment or disfigurement
(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which can cause injury of sufficient severity to threaten life following a single exposure lasting seconds, minutes, or hours, or following ingestion of a single dose
(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years can cause injury to skin or mucous membranes of sufficient severity to threaten life or cause permanent impairment, which disfigurement, or irreversible change
(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause death or serious physical impairment following continuous or repeated exposures to small amounts extending over periods of days, months, or years

*Sax, N. I., Dangerous Properties of Industrial Materials, Van Nostrand Rheinhold Co., New York, New York, 4th edition, 1975.
**Sax, N. I., Dangerous Properties of Industrial Materials, Van Nostrand Rheinhold Co., New York, New York, 5th edition, 1979.

TABLE 7—NFPA TOXICITY RATINGS*

0 Materials which on exposure under fire conditions would offer no health hazard beyond that of ordinary combustible material.
1 Materials only slightly hazardous to health. It may be desirable to wear self-contained breathing apparatus.
2 Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.
3 Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing, including self-contained breathing apparatus, rubber gloves, boots and bands around legs, arms and waist should be provided. No skin surface should be exposed.
4 A few whiffs of the gas or vapor could cause death, or the gas, vapor, or liquid could be fatal on penetrating the fire fighters' normal full protective clothing which is designed for resistance to heat. For most chemicals having a Health 4 rating, the normal full protective clothing available to the average fire department will not provide adequate protection against skin contact with these materials. Only special protective clothing designed to protect against the specific hazard should be worn.

*National Fire Protection Association, *National Fire Codes*, Vol. 13, No. 49, 1977.

Table 4 presents values for some common compounds.

Hazardous waste quantity includes all hazardous substances at a facility (as received) except that with a containment value of 0. Do not include amounts of contaminated soil or water; in such cases, the amount of contaminating hazardous substance may be estimated.

On occasion, it may be necessary to convert data to a common unit to combine them. In such cases, 1 ton=1 cubic yard=4 drums and for the purposes of converting bulk storage, 1 drum=50 gallons. Assign a value as follows:

Tons in cubic yards	Number of drums	Assigned value
0	0	0
1-10	1-40	1
11-62	41-250	2
63-125	251-500	3
126-250	501-1,000	4
251-625	1,001-2,500	5
626-1,250	2,501-5,000	6
1,251-2,500	5,001-10,000	7
>2,500	>10,000	8

3.3 *Targets. Ground water use* indicates the nature of the use made of ground water drawn from the aquifer of concern within 3 miles of the hazardous substance, including the geographical extent of the measurable concentration in the aquifer. Assign a value using the following guidance:

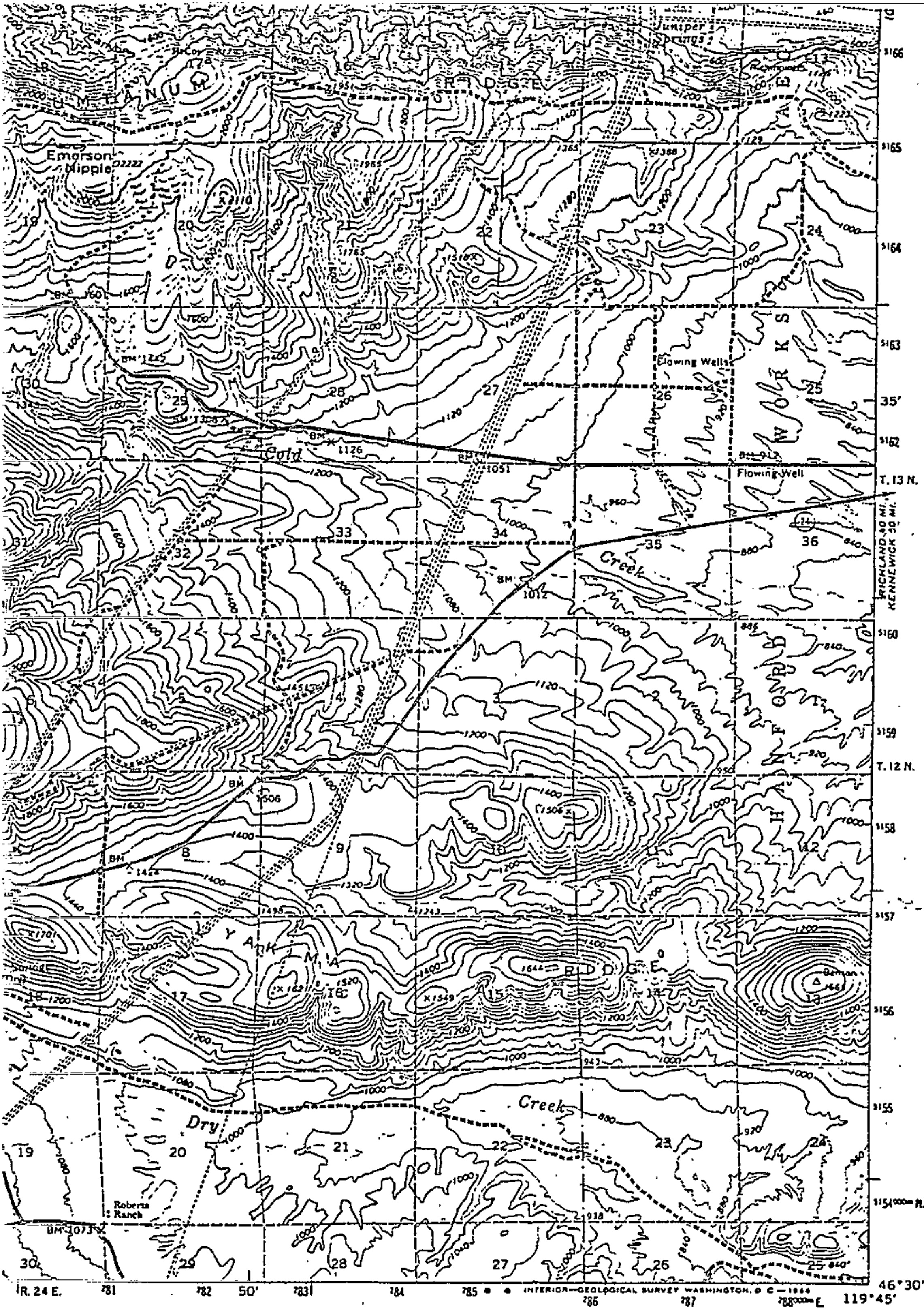
Ground water use	Assigned value
Unusable (e.g., extremely saline aquifer, extremely low yield, etc.)	0
Commercial, industrial or irrigation and another water source presently available, not used, but usable	1
Drinking water with municipal water from alternate unthreatened sources presently available (i.e., minimal hookup requirements), or commercial, industrial or irrigation with no other water source presently available	2
Drinking water, no municipal water from alternate unthreatened sources presently available	3

Distance to nearest well and *population served* have been combined in the matrix below to better reflect the important relationship between the distance of a population from hazardous substances and the size of the population served by ground water that might be contaminated by those substances. To determine the overall value for this combined factor, score each individual-

REFERENCE 8

U.S.G.S. Maps of the area around the 100 Area:

Coyote Rapids, Wash 15 Minute Map
Smyrna, Wash 15 Minute Map
Corfu, Wash 15 Minute Map
Priest Rapids, Wash 15 Minute Map
Hanford, Wash 15 Minute Map



2 3 4 MILES

12000 15000 18000 21000 FEET

3 4 5 KILOMETERS

FEET
T CONTOURS
VEL

CCURACY STANDARDS
.DO 80225, OR WASHINGTON, D.C. 20242
BOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Medium-duty Light-duty

Unimproved dirt

State Route

The NW, SW, and SE quarters also covered by 7.5 minute, 1:24 000-scale maps: Priest Rapids 1950, Cairn Hope Peak 1950, and Emerson Nipple 1950

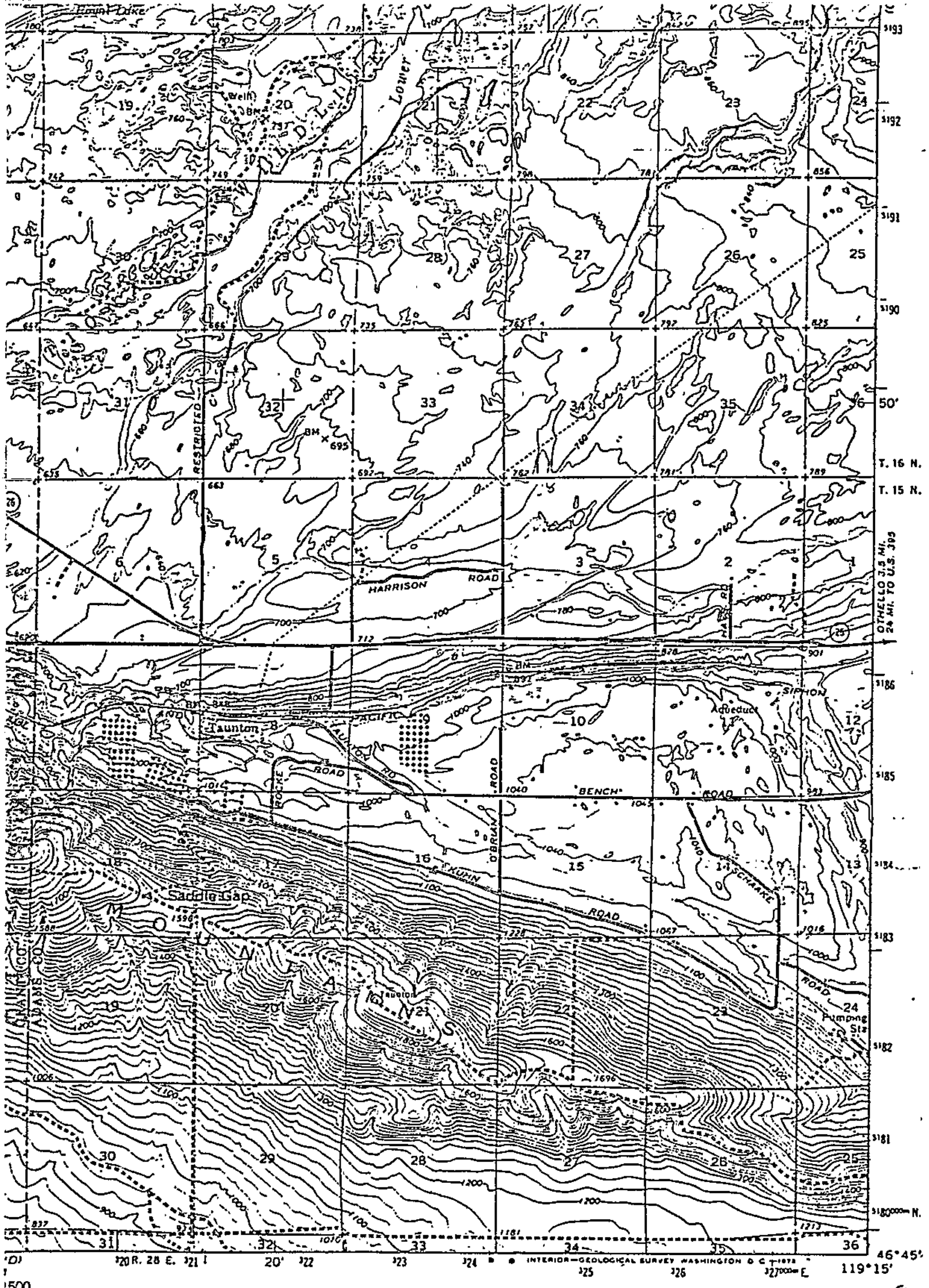
(CORRAL CANYON)
2076 I

PRIEST RAPIDS, WASH.
N4630—W11945/15

1965

AMS 2077 III—SERIES V791

6
9976



(MESA)
2177 II

1500

4 MILES

21000 FEET

5 KILOMETERS

AL 20 FEET
EA LEVEL

ROAD CLASSIFICATION

Medium-duty ——— Light-duty ———

Unimproved dirt ---------

State Route

WASHINGTON

QUADRANGLE LOCATION

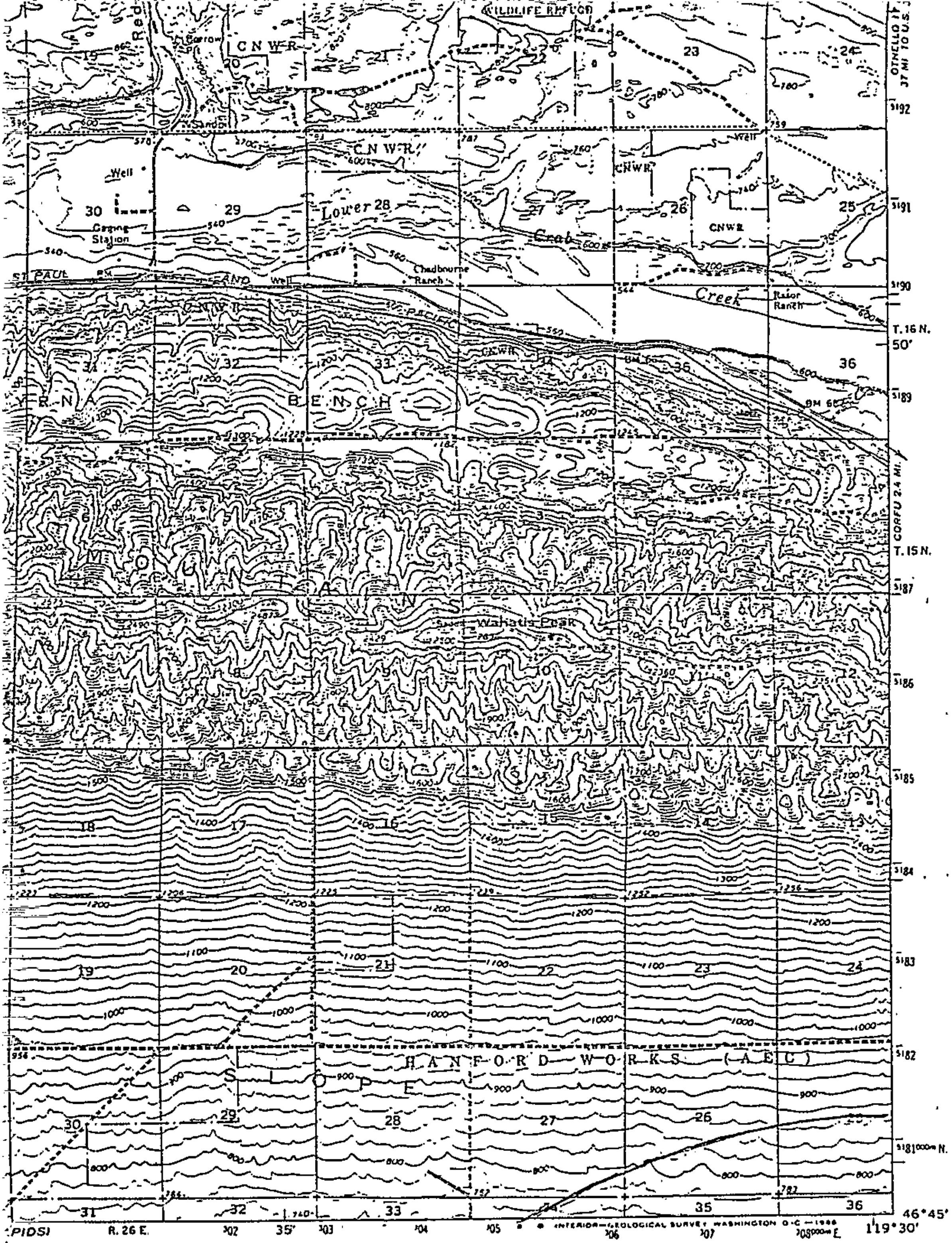
MAP ACCURACY STANDARDS
OLORADO 80225, OR WASHINGTON, D. C. 20242
D SYMBOLS IS AVAILABLE ON REQUEST

CORFU, WASH.
N4645—W11915/15

1965

AMS 2177 IV—SERIES V791

7
9976



500

2 3 4 MILES

12000 15000 18000 21000 FEET

3 4 5 KILOMETERS

AL 20 FEET
SEA LEVEL

MAP ACCURACY STANDARDS
OLORADO 80225, OR WASHINGTON, D. C. 20242
D SYMBOLS IS AVAILABLE ON REQUEST

(HANFORD)
2177 III

ROAD CLASSIFICATION

Medium-duty Light-duty

Unimproved dirt

State Route

WASHINGTON

QUADRANGLE LOCATION

SMYRNA, WASH.
N4645—W11930/15

1965

AMS 2077 I—SERIES V791

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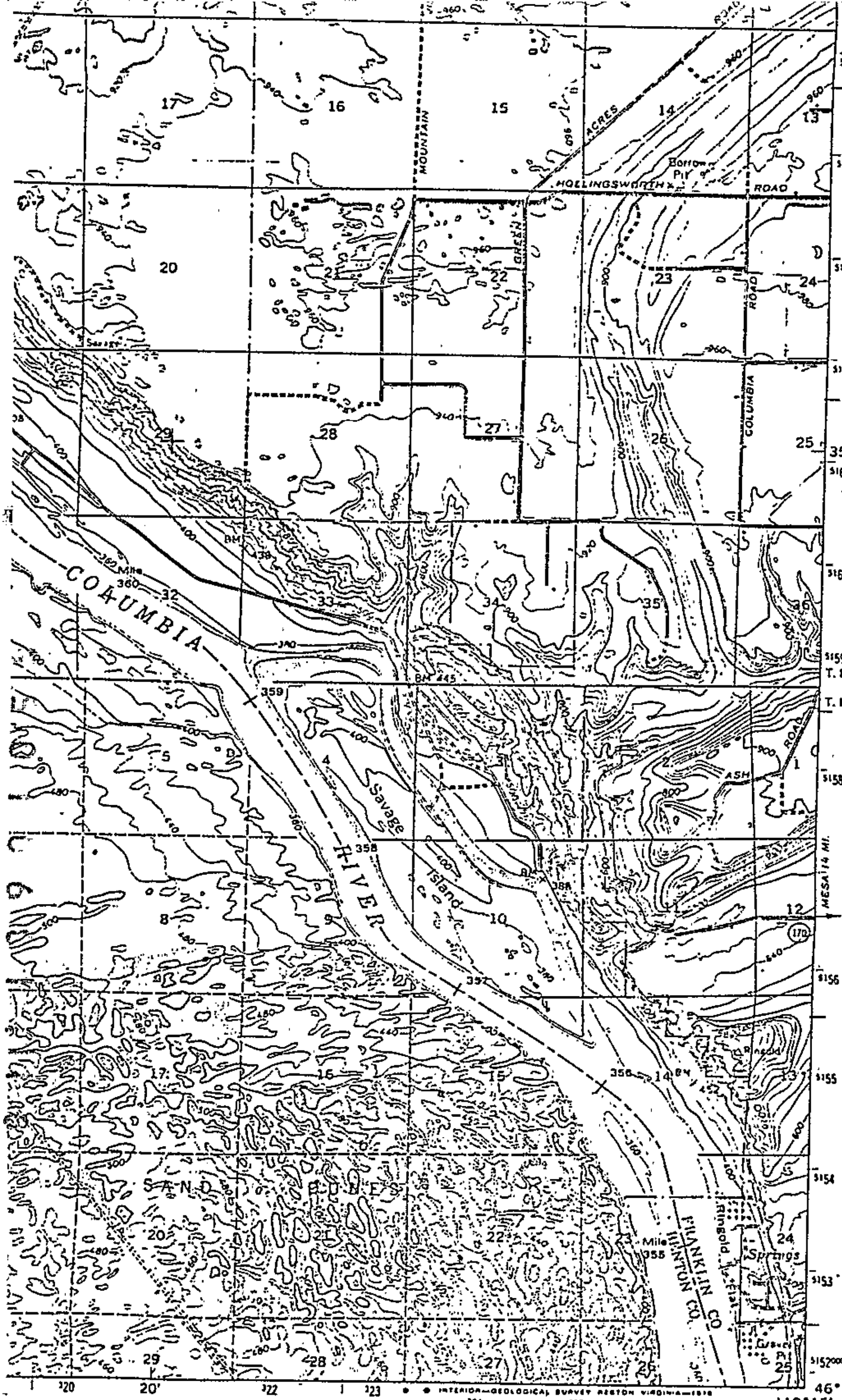
9976



3 4 MILES

000 18000 21000 FEET

4 5 KILOMETERS

ROAD CLASSIFICATION

Heavy duty ———— Light duty ————

Medium duty ———— Unimproved dirt - - - - - - -

State Route

(ELTOPIA) 2176 I

WASHINGTON

QUADRANGLE LOCATION

RDS

STON, VIRGINIA 22092

N REQUEST

HANFORD, WASH.

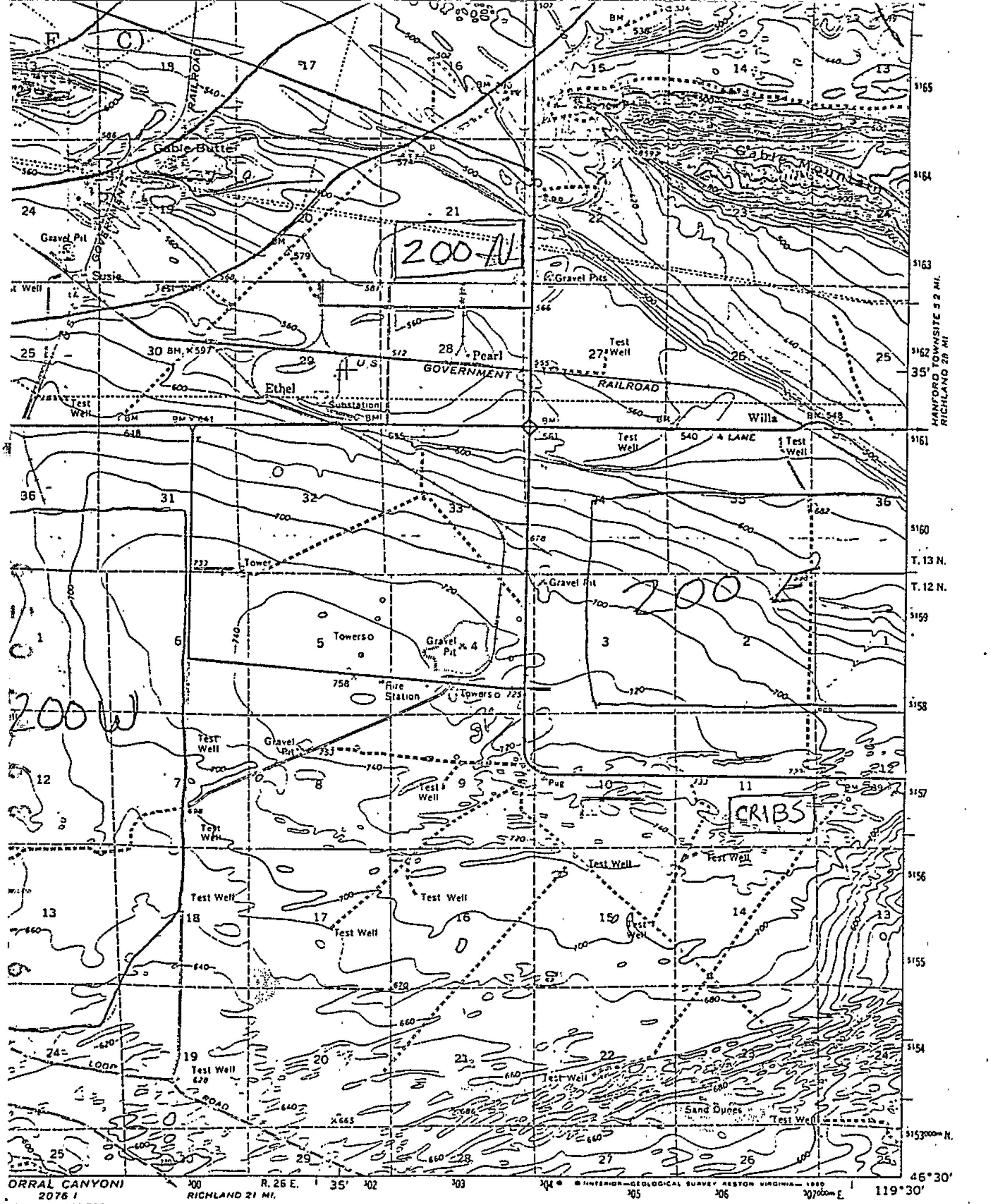
N4630—W11915/15

1965

AMS 2177 III—SERIES V791

9

9976



SCALE 1:62500

2 3 4 MILES

9000 12000 15000 18000 21000 FEET

2 3 4 5 KILOMETERS

UR INTERVAL 20 FEET
DETIC VERTICAL DATUM OF 1929

ROAD CLASSIFICATION

Heavy-duty ———— Light-duty ————
Medium-duty ———— Unimproved dirt - - - - - - -
State Route

WASHINGTON
QUADRANGLE LOCATION

ITH NATIONAL MAP ACCURACY STANDARDS
. DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
PHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

COYOTE RAPIDS, WASH.
N4630—W11930/15

1965

DMA 2077 II—SERIES V791

10
9976

REFERENCE 9

<u>Waste Management Operations</u>, Volume 1, ERDA-1538

TABLE II.1-5a (Continued)

CHARACTERIZATION OF 300 NORTH AND WYE BURIAL GROUNDS

- Field survey of waste disposal sites begun late FY-1975
- Drilling of current series of sampling wells completed late FY-1976
- Estimate of any migration of radionuclides based on available data completed early FY-1977
- Final report and disposal site maps completed and issued late FY-1977

PLUTONIUM RECOVERY

- Detailed schedules will be developed based on the results of the 216-Z-9 Crib plutonium recovery program.

FISSION PRODUCT RECOVERY

- No schedule for recovery has been established.

II.1.1.3 Plant Water Usage

Sanitary and process water for the Hanford Reservation operations are supplied from a number of different locations (Table II.1-6). The 100-B pumphouse, with the 100-D as backup, supplies water to 100-B-C, 100-D, 100-H, 100-F, and 200 Areas. (All of these areas are shown on Figure II.1-1.) A water plant at 100-N Area supplies sanitary and process water to both 100-N and the WPPSS generating station located adjacent to 100-N. The 300 Area pumphouse supplies all water needs for the 300 Area. The City of Richland water supply system is intertied to the 300 Area system as an emergency backup. Various wells in the 600 Areas on the site supply both sanitary and process water.

An average of 440 cfs (0.4% of annual average flow) of Columbia River water is continuously withdrawn, mainly for cooling purposes. Most of this water is discharged directly back to the river as nonradioactive disposal. In addition, approximately 34.7 cfs (less than 0.03% of the total annual average flow) of Columbia River water is withdrawn and discharged to the ground as sanitary and industrial wastes. Wells supply approximately 73,000 gal/day for sanitary and minor irrigation use which is almost entirely discharged to the ground.

II.1.1.4 Waste Inventories [X.18]

Multiple disposal sites for radioactive waste have been used at Hanford during its 30-yr history. The choice of disposal site is based on many factors including half-life and toxicity of the elements involved, quantity of material to be discarded, proximity to water table and/or the Columbia River, and optimum personnel radiation exposure and contamination control. The use of many of these sites has been terminated.

The waste inventory data reported subsequently and in greater detail in Appendix II.1-C for cribs, burial grounds, ponds, ditches, specific retention sites, and unplanned releases are subject to variations in sample collection and analysis.

High-level waste streams are analyzed for plutonium, uranium and neptunium. Fission product content is calculated from irradiation history. The total contents of all waste tanks are known with fair precision, although the contents of individual tanks and, to some extent, of individual tank farms are less certain because of transfers among tanks and farms.

Discharges to cribs, specific retention sites, ponds and ditches are based on line samples. Since the concentration of radionuclides in these streams is often low, accuracy is low and considerable uncertainty is involved. In some cases, particularly for discharges to ponds and ditches, the radioactivity is below limit of detection and the results are therefore reported as "less-than" figures.

Unplanned releases of liquids to grounds are based on estimates of volumes involved and of concentrations of the radionuclides in the stream. Gaseous releases are based on stack samples.

Ref. 9.1

TABLE II.1-6

PLANT WATER USE

Plant or Facility	Source of Supply	Primary Use
100-B	Columbia River 100-B Pumphouse	Process water
100-D	Columbia River 100-D Pumphouse	Process water
100-K	From 100-K Pumphouse	Process water
100-N	Columbia River-100-N Pumphouse	Process, sanitary and cooling water
100-F	From 100-B Pumphouse	Process water
200 Areas	100-B Pumphouse Well 299-E26-6 Wells 299-E28-11 and 15	Process and cooling water Emergency cooling water supply Emergency process supply
300 Area	Columbia River 300 Area Pumphouse	Process and sanitary 331 Fish Ponds
FFTF	Wells 699-S0-7 699-S0-8 699-S1-7B	Construction and Sanitary
Atm. Physics	100-B Pumphouse	Sanitary
609 Fire Sta. (100 Area Central)	100-B Pumphouse	Sanitary
609 A Fire Sta. (200 Area Central)	100-B Area	Sanitary
6652C (Aeronomy)	Rattlesnake Springs	Sanitary
6652I (Ale Hq)	Well 699-26-89	Sanitary and Irrigation
Emergency Relocation Ctr.	Well 699-S18-51	Sanitary
BY Telephone Exchange	Well 699-50-28A	Sanitary
Hanford Road Maintenance	Well 699-Han-9	Industrial and Sanitary
Vernita Park	Wells 699-72-101A, B and C	Sanitary and Irrigation

Reported quantities of radioactivity in burial grounds or storage tunnels are estimates based on operating history and radiation levels of the equipment or waste buried. Generally, these data are of greater uncertainty than liquid and gaseous streams since there is no practical method by which a representative sample, particularly of large equipment pieces, can be obtained.

Overall, however, the accuracy of the inventory total is believed to be within a factor of two, probably within 50% or better. The reported inventories in this final environmental impact statement have been adjusted to a single significant figure to reflect the uncertainties in the data.

II.1.1.4.1 Contained Solids and Liquids

II.1.1.4.1.1 Disposal Sites

The approximate inventories of solid waste disposal in the 100 Areas through 1972 summarized below are shown in Appendix II.1-B, Part 3. These inventories are corrected for decay through the end of 1972.

Ref. 9.2

REFERENCE 10

<u>Inductively Coupled Plasma Method</u>, Method 6010

Chromium Method of Analysis.

METHOD 6010

INDUCTIVELY COUPLED PLASMA METHOD

1.0 Scope and Application

1.1 Method 6010 is approved for determining the concentration of trace elements in mobility procedure extracts (exclusive of arsenic and selenium), wastes, and soils.

1.2 This method may be used for the determination of total elements in groundwater if the detection limit is less than primary interim drinking water standards or less than background levels.

1.3 All samples must be subjected to an appropriate dissolution step prior to analysis. (Refer to Section 2.1.)

1.4 Precaution must be taken to ensure that all spectral, chemical and physical interferences are detected and the appropriate corrective measures taken.

1.5 Use of this method is restricted to experienced spectroscopists.

1.6 Elements for which Method 6010 is an approved procedure are:

Aluminum	Cobalt	Potassium
Antimony	Copper	Silica
Barium	Iron	Silver
Beryllium	Lead	Sodium
Boron	Magnesium	Thallium
Cadmium	Manganese	Vanadium
Calcium	Molybdenum	Zinc
Chromium	Nickel	

2.0 Summary of Method

2.1 Prior to analysis by Method 6010, samples must be prepared for sample introduction. The method of sample preparation will vary according to the sample matrix. Aqueous samples are subjected to the acid digestion procedure described in this method. Sludge-type samples are prepared using the procedure described in Method 3050. For samples containing oils, greases or waxes, the procedures described in Methods 3030 and 3040 may be applicable.

2.2 Method 6010 describes a technique for the simultaneous or sequential multielement determination of trace elements in solution. The basis of the method is the measurement of atomic emission by an optical spectroscopic technique. Samples are nebulized and the aerosol that is produced is transported to the plasma torch where excitation occurs. Characteristic atomic-line emission spectra are produced by a radio-frequency inductively coupled plasma

(ICP). The spectra are dispersed by a grating spectrometer and the intensities of the lines are monitored by photomultiplier tubes. The photocurrents from the photomultiplier tubes are processed and controlled by a computer system. A background correction technique is required to compensate for variable background contribution to the determination of trace elements. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background intensity measurement, on either or both sides of the analytical line, will be determined by the complexity of the spectrum adjacent to the analyte line. The position used must be free of spectral interference and reflect the same change in background intensity as occurs at the analyte wavelength measured. Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. The possibility of additional interferences named in 3.1 (and tests for their presence as described in 3.2) should also be recognized and appropriate corrections made.

3.0 Interferences

3.1 Several types of interference effects may contribute to inaccuracies in the determination of trace elements. They can be summarized as follows:

3.1.1 Spectral interferences can be categorized as (1) overlap of a spectral line from another element; (2) unresolved overlap of molecular band spectra; (3) background contribution from continuous or recombination phenomena; and (4) background contribution from stray light from the line emission of high concentration elements. The first of these effects can be compensated by utilizing a computer correction of the raw data, requiring the monitoring and measurement of the interfering element. The second effect may require selection of an alternate wavelength. The third and fourth effects can usually be compensated by a background correction adjacent to the analyte line. In addition, users of simultaneous multielement instrumentation must assume the responsibility of verifying the absence of spectral interference for an element that could occur in a sample but for which there is no channel in the instrument array. Listed in Table 2 are some interference effects for the recommended wavelengths given in Table 1. The data in Table 2 are intended for use only as a rudimentary guide for indicating potential spectral interferences. For this purpose, linear relations between concentration and intensity for the analytes and the interferents can be assumed.

3.1.1.1 The interference information, which was collected at the Ames Laboratory,[1] is expressed as analyte concentration equivalents (i.e., false analyte concentrations) arising from 100 mg/liter of the interference element. The suggested use of this

[1]Ames Laboratory, U.S. DOE, Iowa State University, Ames, Iowa 50011.

TABLE 1. RECOMMENDED WAVELENGTHS AND ESTIMATED INSTRUMENTAL DETECTION LIMITS

Element	Wavelength[a] (nm)	Estimated detection limit[b] (µg/l)
Aluminum	308.215	45
Arsenic	193.696	53[c]
Antimony	206.833	32
Barium	455.403	2
Beryllium	313.042	0.3
Boron	249.773	5
Cadmium	226.502	4
Calcium	317.933	10
Chromium	267.716	7
Cobalt	228.616	7
Copper	324.754	6
Iron	259.940	7
Lead	220.353	42
Magnesium	279.079	30
Manganese	257.610	2
Molybdenum	202.030	8
Nickel	231.604	15
Potassium	766.491	see[d]
Selenium	196.026	75[c]
Silica (SiO_2)	288.158	58
Silver	328.068	7
Sodium	588.995	29
Thallium	190.864	40
Vanadium	292.402	8
Zinc	213.856	2

[a]The wavelengths listed are recommended because of their sensitivity and overall acceptance. Other wavelengths may be substituted if they can provide the needed sensitivity and are treated with the same corrective techniques for spectral interference (see 3.1.1). In time, other elements may be added as more information becomes available and as required.

[b]The estimated instrumental detection limits as shown are taken from "Inductively Coupled Plasma-Atomic Emission Spectroscopy-Prominent Lines," EPA-600/4-79-017. They are given as a guide for an instrumental limit. The actual method detection limits are sample-dependent and may vary as the sample matrix varies.

[c]Method may not be applicable for groundwater analysis for these metals.

[d]Highly dependent on operating conditions and plasma position.

TABLE 2. ANALYTE CONCENTRATION EQUIVALENTS
ARISING FROM INTERFERENTS AT THE 100 MG/L LEVEL

		Interferent (mg/l)									
Analyte	Wavelength (nm)	Al	Ca	Cr	Cu	Fe	Mg	Mn	Ni	Ti	V
Aluminum	308.215	--	--	--	--	--	--	0.21	--	--	1.4
Antimony	206.833	0.47	--	2.9	--	0.08	--	--	--	0.25	0.45
Arsenic	193.696	1.3	--	0.44	--	--	--	--	--	--	1.1
Barium	455.403	--	--	--	--	--	--	--	--	--	--
Beryllium	313.042	--	--	--	--	--	--	--	--	0.04	0.05
Boron	249.773	0.04	--	--	--	0.32	--	--	--	--	--
Cadmium	226.502	--	--	--	--	0.03	--	--	0.02	--	--
Calcium	317.933	--	--	0.08	--	0.01	0.01	0.04	--	0.03	0.03
Chromium	267.716	--	--	--	--	0.003	--	0.04	--	--	0.04
Cobalt	228.616	--	--	0.03	--	0.005	--	--	0.03	0.15	--
Copper	324.754	--	--	--	--	0.003	--	--	--	0.05	0.02
Iron	259.940	--	--	--	--	--	--	0.12	--	--	--
Lead	220.353	0.17	--	--	--	--	--	--	--	--	--
Magnesium	279.079	--	0.02	0.11	--	0.13	--	0.25	--	0.07	0.12
Manganese	257.610	0.005	--	0.01	--	0.002	0.002	--	--	--	--
Molybdenum	202.030	0.05	--	--	--	0.03	--	--	--	--	--
Nickel	231.604	--	--	--	--	--	--	--	--	--	--
Selenium	196.026	0.23	--	--	--	0.09	--	--	--	--	--
Silicon	288.158	--	--	0.07	--	--	--	--	--	--	0.01
Sodium	588.995	--	--	--	--	--	--	--	--	0.08	--
Thallium	190.864	0.30	--	--	--	--	--	--	--	--	--
Vanadium	292.402	--	--	0.05	--	0.005	--	--	--	0.02	--
Zinc	213.856	--	--	--	0.14	--	--	--	0.29	--	--

Ref. 10.4

information is as follows: Assume that arsenic (at 193.696 nm) is to be determined in a sample containing approximately 10 mg/liter of aluminum. According to Table 2, 100 mg/liter of aluminum would yield a false signal for arsenic equivalent to approximately 1.3 mg/liter. Therefore, 10 mg/liter of aluminum would result in a false signal for arsenic equivalent to approximately 0.13 mg/liter. The reader is cautioned that other analytical systems may exhibit somewhat different levels of interference than those shown in Table 2, and that the interference effects must be evaluated for each individual system.

3.1.1.2 Only those interferents listed were investigated, and the blank spaces in Table 2 indicate that measurable interferences were not observed for the interferent concentrations listed in Table 3. Generally, interferences were discernible if they produced peaks or background shifts corresponding to 2-5% of the peaks generated by the analyte concentrations also listed in Table 3.

3.1.1.3 At present, information on the listed silver and potassium wavelengths is not available but it has been reported that second order energy from the magnesium 383.231-nm wavelength interferes with the listed potassium line at 766.491 nm.

3.1.2 Physical interferences are generally considered to be effects associated with the sample nebulization and transport processes. Such properties as change in viscosity and surface tension can cause significant inaccuracies especially in samples which may contain high dissolved solids or acid concentrations. The use of a peristaltic pump may lessen these interferences. If these types of interferences are operative, they must be reduced by diluting the sample and/or utilizing standard addition techniques. Another problem which can occur from high dissolved solids is salt buildup at the tip of the nebulizer. This affects aerosol flow rate, causing instrumental drift. Wetting the argon prior to nebulization, the use of a tip washer, or sample dilution have been used to control this problem. Also, the use of a high solid nebulizer can reduce salt build-up in the nebulizer and can also prevent drifting and loss of sensitivity in the instrument. In addition, it has been reported that better control of the argon flow rate improves instrument performance. This is accomplished with the use of mass flow controllers.

3.1.3 Chemical interferences are characterized by molecular compound formation, ionization effects and solute vaporization effects. Normally these effects are not pronounced with the ICP technique; however, if observed they can be minimized by careful selection of operating conditions (that is, incident power, observation position, and so forth), by buffering of the sample, by matrix matching, and by standard addition procedures. These types of interferences can be highly dependent on matrix type and the specific analyte element.

TABLE 3. INTERFERENT AND ANALYTE ELEMENTAL CONCENTRATIONS USED FOR INTERFERENCE MEASUREMENTS IN TABLE 2

Analytes	mg/liter	Interferents	mg/liter
Al	10	Al	1,000
As	10	Ca	1,000
B	10	Cr	200
Ba	1	Cu	200
Be	1	Fe	1,000
Ca	1	Mg	1,000
Cd	10	Mn	200
Co	1	Ni	200
Cr	1	Ti	200
Cu	1	V	200
Fe	1		
Mg	1		
Mn	1		
Mo	10		
Na	10		
Ni	10		
Pb	10		
Sb	10		
Se	10		
Si	1		
Tl	10		
V	1		
Zn	10		

3.2 It is recommended that whenever a new or unusual sample matrix is encountered, a series of tests be performed prior to reporting concentration data for analyte elements. These tests, as outlined in 3.2.1 through 3.2.4, will ensure the analyst that neither positive nor negative interferences will have on any of the analyte elements and distort the accuracy of the reported values.

3.2.1 Serial dilution: If the analyte concentration is sufficiently high (minimally a factor of 10 above the instrumental detection limit after dilution), an analysis of a dilution should agree within 5 percent of the original determination (or within some acceptable control limit that has been established for that matrix). If not, a chemical or physical interference effect should be suspected.

3.2.2 Spike addition: A spike addition added at a minimum level of 10x the instrumental detection limit (maximum 100x) to the original determination should be recovered to within 90 to 110 percent or within the established control limit for that matrix. If not, a matrix effect should be suspected. The use of a standard addition analysis procedure can usually compensate for this effect. CAUTION: The standard addition technique does not detect coincident spectral overlap. If suspected, use of computerized compensation, an alternate wavelength, or comparison with an alternate method is recommended (see 3.2.3).

3.2.3 Comparison with alternate method of analysis: When investigating a new sample matrix, comparison tests may be performed with other analytical techniques such as atomic absorption spectrometry or other approved methodology.

3.2.4 Wavelength scanning of analyte line region: If the appropriate equipment is available, wavelength scanning can be performed to detect potential spectral interferences.

4.0 Apparatus and Materials

4.1 Inductively coupled plasma-atomic emission spectrometer

4.1.1 Computer-controlled atomic emission spectrometer with background correction.

4.1.2 Radiofrequency generator.

4.1.3 Argon gas supply, welding grade or better.

4.2 Operating conditions: Because of the differences between various makes and models of satisfactory instruments, no detailed operating instructions can be provided. Instead, the analyst should follow the instructions provided by the manufacturer of the particular instrument. Sensitivity, instrumental detection limit, precision, linear dynamic range, and interference effects must be investigated and established for each individual analyte line on that particular instrument. It is the responsibility of the analyst (1) to verify that the instrument configuration and operating conditions used satisfy the analytical requirements and (2) to maintain quality control data confirming instrument performance and analytical results.

5.0 Reagents

5.1 Acids used in the preparation of standards and for sample processing must be ultra-high purity grade or equivalent. Redistilled acids are acceptable.

5.1.1 Acetic acid, conc.

5.1.2 Hydrochloric acid, conc.

5.1.3 Hydrochloric acid (1:1): Add 500 ml conc. HCl to 400 ml Type II water and dilute to 1 liter.

5.1.4 Nitric acid, conc.

5.1.5 Nitric acid (1:1): Add 500 ml conc. HNO_3 to 400 ml Type II water and dilute to 1 liter.

5.2 Type II water: Prepare by passing distilled water through a mixed bed of cation and anion exchange resins. Use Type II water for the preparation of all reagents, calibration standards, and as dilution water. The purity of this water must be equivalent to or better than ASTM Type II reagent water of Specification D1193.

5.3 Standard stock solutions may be purchased or prepared from ultra-high purity grade chemicals or metals. All salts must be dried for 1 hr at 105° C unless otherwise specified. (CAUTION: Many metal salts are extremely toxic and may be fatal if swallowed. Wash hands thoroughly after handling.) Typical stock solution preparation procedures follow.

5.3.1 Aluminum solution, stock, 1 ml=100 µg Al: Dissolve 0.100 g of aluminum metal in an acid mixture of 4 ml of (1:1) HCl and 1 ml of conc. HNO_3 in a beaker. Warm gently to dissolve. When solution is complete, transfer quantitatively to a one liter flask and add an additional 10 ml of (1:1) HCl and dilute to 1,000 ml with Type II water.

5.3.2 Antimony solution, stock, 1 ml=100 µg Sb: Dissolve 0.2669 g $K(SbO)C_4H_4O_6$ in Type II water, add 10 ml (1:1) HCl and dilute to 1,000 ml with Type II water.

5.3.3 Arsenic solution, stock, 1 ml=100 µg As: Dissolve 0.1320 g of As_2O_3 in 100 ml of Type II water containing 0.4 g NaOH. Acidify the solution with 2 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.4 Barium solution, stock, 1 ml=100 µg Ba: Dissolve 0.1516 g $BaCl_2$ (dried at 250° C for 2 hr) in 10 ml Type II water with 1 ml (1:1) HCl. Add 10.0 ml (1:1) HCl and dilute to 1,000 ml with Type II water.

5.3.5 Beryllium solution, stock, 1 ml=100 µg Be: Do not dry. Dissolve 1.966 g $BeSO_4 \cdot 4H_2O$ in Type II water, add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.6 Boron solution, stock, 1 ml=100 µg B: Do not dry. Dissolve 0.5716 g anhydrous H_3BO_3 in Type II water and dilute to 1,000 ml. Keep in a tightly stoppered bottle, and store in a desiccator to prevent the entrance of atmospheric moisture.

5.3.7 Cadmium solution, stock, 1 ml=100 µg Cd: Dissolve 0.1142 g CdO in a minimum amount of of (1:1) HNO_3. Heat to increase rate of dissolution. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.8 Calcium solution, stock, 1 ml=100 µg Ca: Suspend 0.2498 g $CaCO_3$ dried at 180° C for 1 hr before weighing in Type II water and dissolve cautiously with a minimum amount of (1:1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.9 Chromium solution, stock, 1 ml=100 µg Cr: Dissolve 0.1923 g CrO_3 in Type II water. When solution is complete, acidify with 10 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.10 Cobalt solution, stock, 1 ml=100 µg Co: Dissolve 0.1000 g of cobalt metal in a minimum amount of (1:1) HNO_3. Add 10.0 ml (1:1) HCl and dilute to 1,000 ml with Type II water.

5.3.11 Copper solution, stock, 1 ml = 100 µg Cu: Dissolve 0.1252 g CuO in a minimum amount of (1+1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

5.3.12 Iron solution, stock, 1 ml=100 µg Fe: Dissolve 0.1430 g Fe_2O_3 in a warm mixture of 20 ml (1:1) HCl and 2 ml of conc. HNO_3. Cool, add an additional 5.0 ml of conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.13 Lead solution, stock, 1 ml=100 µg Pb: Dissolve 0.1599 g $Pb(NO_3)_2$ in a minimum amount of (1:1) HNO_3. Add 10.0 ml (1:1) HNO_3 and dilute to 1,000 ml with Type II water.

5.3.14 Magnesium solution, stock, 1 ml=100 µg Mg: Dissolve 0.1658 g MgO in a minimum amount of (1:1) HNO_3. Add 10.0 ml (1:1) conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.15 Manganese solution, stock, 1 ml=100 µg Mn: Dissolve 0.1000 g of manganese metal in the acid mixture (10 ml conc. HCl and 1 ml conc. HNO_3) and dilute to 1,000 ml with Type II water.

5.3.16 Molybdenum solution, stock, 1 ml=100 µg Mo: Dissolve 0.2043 g $(NH_4)_2MoO_4$ in Type II water and dilute to 1,000 ml with Type II water.

5.3.17 Nickel solution, stock, 1 ml=100 µg Ni: Dissolve 0.1000 g of nickel metal in 10.0 ml hot conc. HNO_3, cool, and dilute to 1,000 ml with Type II water.

5.3.18 Potassium solution, stock, 1 ml=100 µg K: Dissolve 0.1907 g KCl, dried at 110° C, in Type II water and dilute to 1,000 ml.

5.3.19 Selenium solution, stock, 1 ml=100 µg Se: Do not dry. Dissolve 0.1727 g H_2SeO_3 in Type II water and dilute to 1,000 ml.

5.3.20 Silica solution, stock, 1 ml=100 µg SiO_2: Do not dry. Dissolve 0.4730 g $Na_2SiO_3 \cdot 9H_2O$ in Type II water. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.21 Silver solution, stock, 1 ml=100 µg Ag: Dissolve 0.1575 g $AgNO_3$ in Type II water and 10 ml conc. HNO_3. Dilute to 1,000 ml with Type II water.

5.3.22 Sodium solution, stock, 1 ml=100 µg Na: Dissolve 0.2542 g NaCl in Type II water. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.23 Thallium solution, stock, 1 ml=100 µg Tl: Dissolve 0.1303 g $TlNO_3$ in Type II water. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.24 Vanadium solution, stock, 1 ml=100 µg V: Dissolve 0.2297 g NH_4VO_3 in a minimum amount of conc. HNO_3. Heat to increase rate of dissolution. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.3.25 Zinc solution, stock, 1 ml=100 µg Zn: Dissolve 0.1245 g ZnO in a minimum amount of dilute HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with Type II water.

5.4 Mixed calibration standard solutions: Prepare mixed calibration standard solutions by combining appropriate volumes of the stock solutions in volumetric flasks (see 5.4.1 through 5.4.5). Add 2 ml of (1:1) HNO_3 and 10 ml of (1:1) HCl and dilute to 100 ml with Type II water (see Note 1 in Section 5.4.5 and Note 6 in Section 7.3). Prior to preparing the mixed standards, each stock solution should be analyzed separately to determine possible spectral interference or the presence of impurities. Care should be taken when preparing the mixed standards that the elements be compatible and stable. Transfer the mixed standard solutions to a FEP fluorocarbon or unused polyethylene bottle for storage. Fresh mixed standards should be prepared as needed with the realization that concentration can change on aging. Calibration standards must be initially verified using a quality control sample and monitored weekly for stability (see 5.6.3). Although not specifically required, some typical calibration standard combinations follow when using those specific wavelengths listed in Table 1.

5.4.1 Mixed standard solution I: Manganese, beryllium, cadmium, lead, and zinc.

5.4.2 Mixed standard solution II: Barium, copper, iron, vanadium, and cobalt.

5.4.3 Mixed standard solution III: Molybdenum, silica, arsenic, and selenium.

5.4.4 Mixed standard solution IV: Calcium, sodium, potassium, aluminum, chromium, and nickel.

5.4.5 Mixed standard solution V: Antimony, boron, magnesium, silver, and thallium.

NOTE 1: If the addition of silver to the recommended acid combination results in an initial precipitation, add 15 ml of Type II water and warm the flask until the solution clears. Cool and dilute to 100 ml with Type II water. For this acid combination, the silver concentration should be limited to 2 mg/l. Silver under these conditions is stable in a tap water matrix for 30 days. Higher concentrations of silver require additional HCl.

5.5 Two types of blanks are required for the analysis. The calibration blank is used in establishing the analytical curve while the reagent blank is used to correct for possible contamination resulting from varying amounts of the acids used in the sample processing.

5.5.1 The calibration blank is prepared by diluting 2 ml of (1:1) HNO_3 and 10 ml of (1:1) HCl to 100 ml with Type II water (see note 6 in Section 7.3). Prepare a sufficient quantity to be used to flush the system between standards and samples.

5.5.2 The reagent blank must contain all the reagents and in the same volumes as used in the processing of the samples. The reagent blank must be carried through the complete procedure and contain the same acid concentration in the final solution as the sample solution used for analysis.

5.6 Standards: In addition to the calibration standards, an instrument check standard, an interference check sample, and a quality control sample are also required for the analyses.

5.6.1 The instrument check standard is prepared by the analyst by combining compatible elements at a concentration equivalent to the midpoint of their respective calibration curves (see 8.5.1).

5.6.2 The interference check is prepared by the analyst in the following manner. Select a representative sample that contains minimal concentrations of the analytes of interest but known concentrations of interfering elements that will provide an adequate test of the correction factors. Spike the sample with the elements of interest at the approximate concentration of either 100 μg/liter or 5 times the estimated detection limits given in Table 1. (For effluent samples of expected high concentrations, spike at an appropriate level.) If the type of samples analyzed are varied, a synthetically prepared sample may be used if the above criteria and intent are met. A limited supply of a synthetic interference check sample will be available from the Quality Assurance Branch of EMSL-Cincinnati.

5.6.3 The quality control sample should be prepared in the same acid matrix as the calibration standards at a concentration near 1 mg/liter and in accordance with the instructions provided by the supplier.

6.0 Sample Collection, Handling, and Preservation

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in Section One of this manual.

6.2 For the determination of trace elements, contamination and loss are of prime concern. Dust in the laboratory environment, impurities in reagents, and impurities on laboratory apparatus which the sample contacts are all sources of potential contamination. Samples containers can introduce either positive or negative errors in the measurement of trace elements by (a) contributing contaminants through leaching or surface desorption and (b) by depleting concentrations through adsorption. Thus the collection and treatment of the sample prior to analysis requires particular attention. Laboratory glassware including the sample bottle (whether polyethylene, polypropylene, or FEP-fluorocarbon) should be thoroughly washed with detergent and tap water; and rinsed with (1:1) nitric acid, tap water, (1:1) hydrochloric acid, tap water, and finally Type II water, in that order (see Notes 2 and 3).

NOTE 2: Chromic acid may be useful to remove organic deposits from glassware; however, the analyst should be cautioned that the glassware must be thoroughly rinsed with water to remove the last traces of chromium. The use of chromic acid can cause a contamination problem for the determination of chromium if the glassware is not rinsed properly. A commercial product, NOCHROMIX, available from Godax Laboratories, 6 Varick Street, New York, NY 10013, may be used in place of chromic acid. Chromic acid should not be used with plastic bottles.

NOTE 3: If it can be documented through an active analytical quality control program using spiked samples and reagent blanks that certain steps in the cleaning procedure are not required for routine samples, those steps may be eliminated from the procedure.

6.3 Aqueous samples must be preserved and pretreated appropriately depending on whether data on dissolved, suspended, or total metals are desired.

6.4 Nonaqueous samples shall be refrigerated when possible, and analyzed as soon as possible.

7.0 Procedure

7.1 The following definitions are intended to clarify the ensuing discussion.

7.1.1 Instrumental detection limit: The concentration equivalent to a signal, due to the analyte, which is equal to three times the standard deviation of a series of twenty replicate measurements of a reagent blank signal at the same wavelength.

7.1.2 Sensitivity: The slope of the analytical curve, i.e., functional relationship between emission intensity and concentration.

7.1.3 Instrument check standard: A multielement standard of known concentration prepared by the analyst to monitor and verify instrument performance on a daily basis (see 5.6.1).

7.1.4 Interference check sample: A solution containing both interfering and analyte elements of known concentration that can be used to verify background and interelement correction factors (see 5.6.2).

7.1.5 Quality control sample: A solution obtained from an outside source having known concentration values to be used to verify the calibration standards (see 5.6.3).

7.1.6 Calibration standards: A series of known standard solutions used by the analyst for calibration of the instrument (i.e., preparation of the the analytical curve; see 5.4).

7.1.7 Linear dynamic range: The concentration range over which the analytical curve remains linear.

7.1.8 Reagent blank: A volume of Type II water containing the same acid matrix as the calibration standards carried through the entire analytical scheme (see 5.5.2).

7.1.9 Calibration blank: A volume of Type II water acidified with HNO_3 and HCl (see 5.5.1).

7.1.10 Method of standard addition: The standard addition technique involves the use of the unknown and unknown plus a known amount of standard (see 7.9.1).

7.2 Sample preparation: Aqueous samples should be prepared according to Section 7.3. Sludge-type samples should be prepared according to Method 3050 and samples containing oils, greases, or waxes may be prepared according to Methods 3030 and 3040. The applicability of a sample preparative technique to a new matrix type must be demonstrated by analyzing spiked sample or relevant standard reference materials.

7.3 Preparation of aqueous samples: For the determination of total elements, choose a measured volume of the well-mixed acid-preserved sample appropriate for the expected level of elements and transfer to a Griffin beaker (see note 5 below). Add 3 ml conc. HNO_3. Place the beaker on a hot plate and evaporate to near dryness cautiously, making certain that the sample does not boil and that no area of the bottom of the beaker is allowed to go dry. Cool the beaker and add another 5-ml portion of conc. HNO_3. Cover the beaker with a watch glass and return to the hot plate. Increase the temperature of the hot plate so that a gentle reflux action occurs. Continue heating, adding acid as necessary, until the digestion is complete (generally indicated when the digestate is light in color or does not change in appearance with continued refluxing). Again, evaporate to near dryness and cool the beaker. Add 10 ml of (1:1) HCl and 15 ml of Type II water per 100 ml final solution and warm the beaker gently for 15 min to dissolve any precipitate or residue resulting from evaporation. Allow to cool, wash down the beaker walls and watch glass with Type II water and filter the sample to remove insoluble material that could clog the nebulizer (see Note 4 below). Adjust the sample to a predetermined volume based on the expected concentrations of elements present. The sample is now ready for analysis (see Note 6 below). Concentrations so determined shall be reported as "total."

NOTE 4: In place of filtering, after diluting and mixing, the sample may be centrifuged or allowed to settle by gravity overnight to remove insoluble material.

NOTE 5: If low determinations of boron are critical, quartz or polypropylene glassware should be used. Polypropylene glassware is generally preferred since it is cheaper and just as accurate as quartz.

NOTE 6: If the sample analysis solution has a different acid concentration from that given in 7.3, but does not introduce a physical interference or affect the analytical result, the same calibration standards may be used.

7.4 Set up instrument with proper operating parameters established in Section 4.2. The instrument must be allowed to become thermally stable before beginning. This usually requires at least 30 min of operation prior to calibration.

7.5 Initiate appropriate operating configuration of computer.

7.6 Profile and calibrate instrument according to instrument manufacturer's recommended procedures, using the typical mixed calibration standard solutions described in Section 5.4. Flush the system with the calibration blank (5.5.1) between each standard (see Note 7 below). (The use of the average intensity of multiple exposures for both standardization and sample analysis has been found to reduce random error.)

NOTE 7: For boron concentrations greater than 500 µg/liter extended flush times of 1 to 2 min may be required.

7.7 Before beginning the sample run, reanalyze the highest mixed calibration standard as if it were a sample. Concentration values obtained should not deviate from the actual values by more than $\pm 5\%$ (or the established control limits, whichever is lower). If they do, follow the recommendations fo the instrument manufacturer to correct for this condition.

7.8 Begin the sample run by flushing the system with the calibration blank solution (5.5.1) between each sample (see Note 7). Analyze the instrument check standard (5.6.1) and the calibration blank (5.5.1) after each 10 samples.

7.9 If it has been found that methods of standard addition are required, the following procedure is recommended.

7.9.1 The standard addition technique involves preparing new standards in the sample matrix by adding known amounts of standard to one or more aliquots of the processed sample solution. This technique compensates for a sample constituent that enhances or depresses the analyte signal, thus producing a different slope from that of the calibration standards. It will not correct for additive interference which causes a baseline shift. The simplest version of this technique is the single-addition method. The procedure is as follows. Two identical aliquots of the sample solution, each of volume V_x, are taken. To the first (labeled A) is added a small volume V_s of a standard analyte solution of concentration c_s. To the second (labeled B) is added the same volume V_s of the solvent. The analytical signals of A and B are measured and corrected for nonanalyte signals. The unknown sample concentration c_x is calculated:

$$c_x = \frac{S_B V_s c_s}{(S_A - S_B)\, V_x}$$

where S_A and S_B are the analytical signals (corrected for the blank) of solutions A and B, respectively. V_s and c_s should be chosen so that S_A is roughly twice S_B on the average. It is best if V_s is made much less than V_x, and thus c_s is much greater than c_x, to avoid excess dilution of the sample matrix. If a separation or concentration step is used, the additions are best made first and carried through the entire procedure. For the results from this technique to be valid, the following limitations must be taken into consideration.

1. The analytical response signals must be linear with respect to concentration.

2. The chemical form of the analyte added must respond the same as the analyte in the sample.

3. The interference effect m st be constant over the working range of concern.

4. The signal must be corrected for any additive interference.

7.10 Calculations: Reagent blanks (5.5.2) should be subtracted from all samples. This is particularly important for digested samples requiring large quantities of acids to complete the digestion. If dilutions were performed, the appropriate factor must be applied to sample values. All results should be reported in mg/liter with up to three significant figures.

8.0 Quality Control

8.1 All quality control data should be maintained and available for easy reference or inspection.

8.2 Dilute samples if they are more concentrated that the highest standard or if they fall on the plateau of a calibration curve.

8.3 Employ a minimum of one procedural blank per sample batch to determine if contamination or any memory effects are occurring.

8.4 Run one duplicate sample for every 10 samples. A duplicate sample is a sample brought through the whole sample preparation process.

8.5 Check the instrument standardization by analyzing appropriate quality control check standards as follows:

8.5.1 Analyze an appropriate instrument check standard (5.6.1) containing the elements of interest at a frequency of 10%. This check standard is used to determine instrument drift. If agreement is not within ±5% of the expected values or within the established control limits, whichever is lower, the analysis is out of control. The analysis should be terminated, the problem corrected, and the instrument recalibrated.

8.5.2 Analyze the calibration blank (5.5.1) at a frequency of 10%. The result should be within the established control limits of 2 standard deviations of the mean value. If not, repeat the analysis two more times and average the three results. If the average is not within the control limit, terminate the analysis, correct the problem, and recalibrate the instrument.

8.5.3 To verify interelement and background correction factors, analyze the interference check sample (5.6.2) at the beginning, end, and at periodic intervals throughout the sample run. Results should fall within the established control limits of 1.5 times the standard deviation of the mean value. If not, terminate the analysis, correct the problem, and recalibrate the instrument.

8.5.4 A quality control sample (5.6.3) obtained from an outside source must first be used for the initial verification of the calibration standards. A fresh dilution of this sample shall be analyzed every week thereafter to monitor their stability. If the results are not within ±5% of the true value listed for the control sample, prepare a new calibration standard and recalibrate the instrument. If this does not correct the problem, prepare a new stock standard and a new calibration standard and repeat the calibration.

8.6 Spiked samples or standard reference materials shall be employed periodically to ensure that correct procedures are being followed and that all equipment is operating properly.

8.7 The method of standard additions shall be used for the analysis of all EP extracts and whenever a sample suffers from matrix interferences.

8.8 The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations listed in Table 1 were obtained using reagent water. Similar results were achieved using representative wastewaters. The MDL actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects.

8.9 In an EPA round-robin phase 1 study, seven laboratories applied the ICP technique to acid-distilled water matrices that had been dosed with various metal concentrates. Table 4 lists the true value, the mean reported value and the mean % relative standard deviation.

REFERENCE 11

Hanford Stream data base printout showing Priest Rapids Dam data as background data

ENVIRONMENTAL SAMPLE ANALYSIS RESULT REPORT

21 DEC 82 to 15 MAR 83

WATER RIVER WATER CUMULATIVE UNFILTERED

Samp #: 1265 PRIEST RAPIDS-RIVER

121/SR 90

use this sample for background

Date Off	Date On	Result +/- 2 Sigma (PCI/L)	Comments
21 DEC 82	23 NOV 82	3.37E-01 +/- 1.83E-01	
18 JAN 83	21 DEC 82	1.89E-01 +/- 2.46E-02	BKG
15 FEB 83	18 JAN 83	1.91E-01 +/- 3.18E-02	
15 MAR 83	15 FEB 83	2.57E-01 +/- 4.11E-02	

Fraction of Results>DL: 4/ 4 Mean: 2.44E-01
Minimum: 1.89E-01 (18 JAN 83) Standard Error of Mean: 8.64E-02
Maximum: 3.37E-01 (21 DEC 82) Standard Deviation: 1.73E-01
Median: 1.91E-01

REFERENCE 12

Investigation of Ground-Water Seepage from Hanford Shoreline of the Columbia River, PNL-5289, November 1984

PNL-5289
UC-41, 11

Investigation of Ground-Water Seepage from the Hanford Shoreline of the Columbia River

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Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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Battelle

PNL-5289

Ref. 12.1

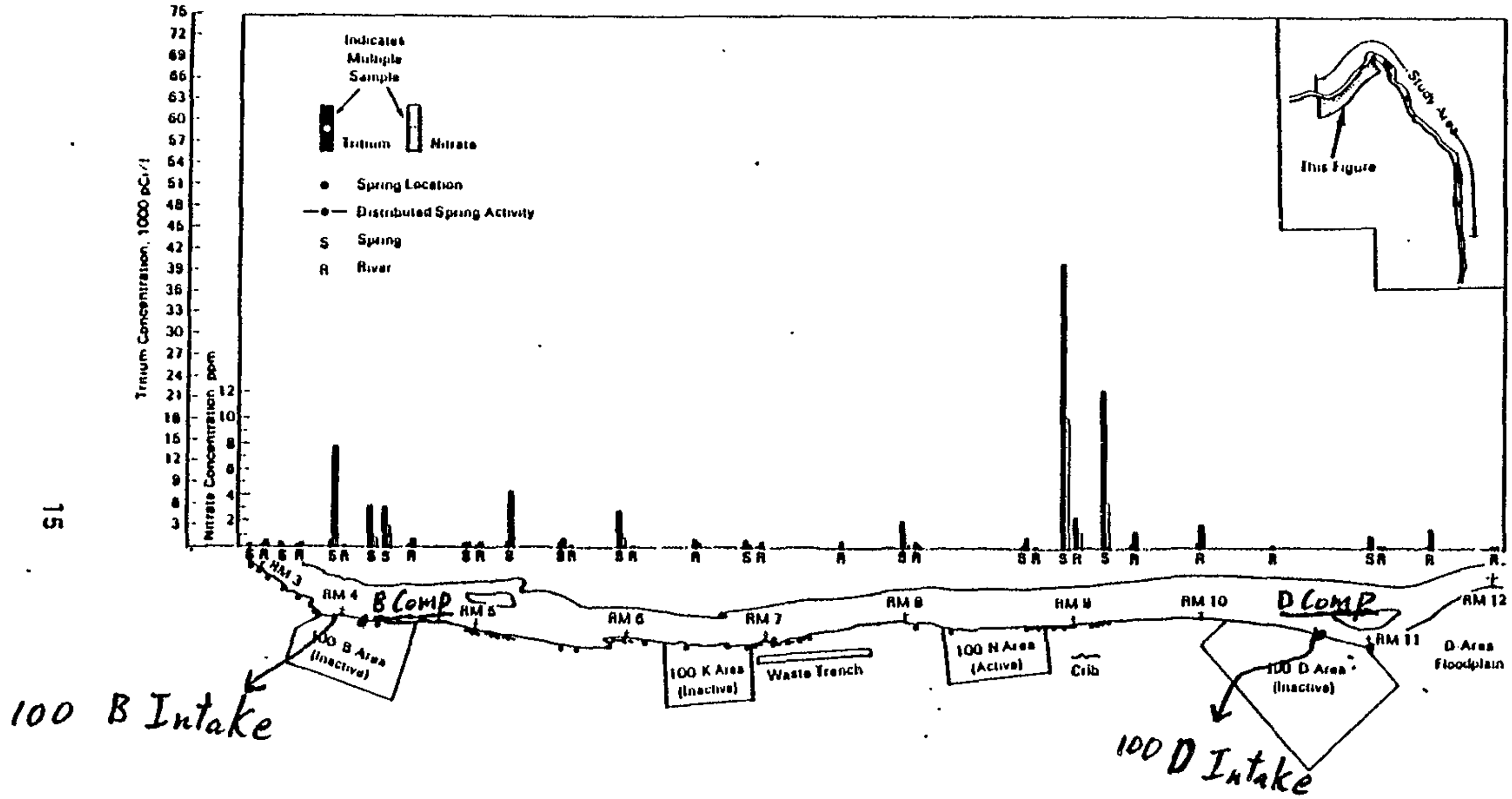

FIGURE 3. Locations and Analytical Results for Spring and River Samples from River Mile 3 through River Mile 12

in PNL-5289

Ref. 12.2

TABLE B.1. Strontium-90 Analyses from Columbia River Samples

River Mile Location	Sample ID	Date Collected	Concentration, pCi/ℓ ±2σ
3.0-5.0	B Comp RW[a]	01/22/83	0.55 ± 0.23
5.5-7.5	K Comp RW	12/18/82	0.18 ± 0.02
8.0-9.5	N Comp RW	12/18/82	28 ± 0.47
10.0-12.0	D Comp RW	12/18/82	1.1 ± 0.05
14.0-17.5	H Comp RW	01/22/83	0.50 ± 0.14
18.0-22.0	F Comp RW	01/22/83	0.93 ± 0.15
Upstream Columbia River Concentration (Average 1983)			0.18 ± 0.22
DOE Concentration Guide (USDOE 1981)			300

DG

use this sample for down grade

DG

because of close sampling date and order magnitude higher difference

(a) Comp-RW denotes composite river water sample comprised of aliquots from immediately preceding river sample locations.

TABLE B.2. Iodine-129 Analyses from Spring and Columbia River Samples

River Mile Location	Sample ID	Date Collected	Concentration, pCi/ℓ ±2σ
27.0	27.0 RW[a]	01/22/83	$3.3x10^{-6} \pm 1.4x10^{-6}$
27.0	27-1 Sp[b]	09/11/83	$1.6x10^{-4} \pm 2.1x10^{-5}$
28.0	28-2 Sp	09/11/83	$6.2x10^{-2} \pm 6.8x10^{-3}$
29.0	29.0 RW	01/22/83	$6.3x10^{-5} \pm 5.0x10^{-6}$
31.75	31-5 Sp	09/11/83	$3.0x10^{-5} \pm 4.0x10^{-6}$
32.5	32-0 Sp	09/11/83	$4.4x10^{-5} \pm 2.7x10^{-5}$
Upstream Columbia River Concentration (1983 Average)			$2.4x10^{-5} \pm 2.6x10^{-5}$
DOE Concentration Guide (USDOE 1981)			60

(a) RW denotes composite river water sample.
(b) Sp denotes river bank spring sample.

(in PNL-5289)

Ref. 12.3

REFERENCE 13

<u>Hanford Reservation Area Worker Census</u>, BNWL-2298, July 1977

Hanford Reservation
Area Worker Census

A Research Report for the
Rockwell Hanford Operations

Battelle

Ref. 13.1

TABLE 1. Concentration of Hanford Reservation Workers by Site

Site	Number of Workers	Percent of Total
100	760	5
200 E&W	2,355	16
WPPSS #1,2,&4	2,905	20
FFTF	2,420	16
300	3,110	21
Battelle, et al.	3,345	22
TOTAL	14,895	100

While the worker counts being reported by Reservation employers are usually shown concentrated around a designated site, in reality a substantial portion of these workers are likely to be distributed over the surrounding area. For convenience, however, they are credited to such particular sites as 200 East, 200 West, WPPSS 1, 2, & 4, etc.

Identification of shift workers posed some reporting difficulties since some firms run four shifts while most of the others conduct their operations in three. The 100 Area was a special problem since these workers operate over a wide area. Regardless, all workers have been accounted for in this census although some of the shift counts may be approximate.

DISTRIBUTION OF WORKERS BY RADII AND COMPASS DIRECTION

Figure 2 maps the distribution of Hanford Reservation workers by work shift over intervals of one-mile radii and 16 compass directions centered at the Purex Plant. These same worker distributions are repeated in Figure 3 without the maped Reservation Area as a background. As a tabulating convenience, sector parcel counts have been rounded to units of 5 and 10, but were adjusted to the total count for the separate companies. (Because of confidentiality, worker counts for the separate companies are not being presented here.) For better readability, sector counts within the first two mile radii from the Purex Plant center are presented separately at the bottom of the figure. Table 2 presents work distribution in detail including a cumulative count of workers and percent of total as distance and direction from the Purex Plant center increases.

REFERENCE 14

Endangered and Threatened Wildlife and Plants, 50 CFR, Part 17, Subpart B, October 86 issued under Part 21 of this chapter; and

(2) Identified in the earliest applicable annual report required to be filed by a permittee under Part 21 of this chapter as in a permittee's possession on November 10, 1978, or as the progeny of such a raptor.

(b) This section does not apply to any raptor intentionally returned to the wild.

[48 FR 31607, July 8, 1983]

Subpart B—Lists

SOURCE: 48 FR 34182, July 27, 1983, unless otherwise noted.

§ 17.11 Endangered and threatened wildlife.

(a) The list in this section contains the names of all species of wildlife which have been determined by the Services to be Endangered or Threatened. It also contains the names of species of wildlife treated as Endangered or Threatened because they are sufficiently similar in appearance to Endangered or Threatened species (see § 17.50 *et seq.*).

(b) The columns entitled "Common Name," "Scientific Name," and "Vertebrate Population Where Endangered or Threatened" define the species of wildlife within the meaning of the Act. Thus, differently classified geographic populations of the same vertebrate subspecies or species shall be identified by their differing geographic boundaries, even though the other two columns are identical. The term "Entire" means that all populations throughout the present range of a vertebrate species are listed. Although common names are included, they cannot be relied upon for identification of any specimen, since they may vary greatly in local usage. The Services shall use the most recently accepted scientific name. In cases in which confusion might arise, a synonym(s) will be provided in parentheses. The Services shall rely to the extent practicable on the *International Code of Zoological Nomenclature.*

(c) In the "Status" column the following symbols are used: "E" for Endangered, "T" for Threatened, and "E [or T] (S/A)" for similarity of appearance species.

(d) The other data in the list are nonregulatory in nature and are provided for the information of the reader. In the annual revision and compilation of this title, the following information may be amended without public notice: the spelling of species' names, historical range, footnotes, references to certain other applicable portions of this title, synonyms, and more current names. In any of these revised entries, neither the species, as defined in paragraph (b) of this section, nor its status may be changed without following the procedures of Part 424 of this title.

(e) The "historic range" indicates the known general distribution of the species or subspecies as reported in the current scientific literature. The present distribution may be greatly reduced from this historic range. This column does not imply any limitation on the application of the prohibitions in the Act or implementing rules. Such prohibitions apply to all individuals of the species, wherever found.

(f)(1) A footnote to the FEDERAL REGISTER publication(s) listing or reclassifying a species is indicated under the column "When listed." Footnote numbers to §§ 17.11 and 17.12 are in the same numerical sequence, since plants and animals may be listed in the same FEDERAL REGISTER document. That document, at least since 1973, includes a statement indicating the basis for the listing, as well as the effective date(s) of said listing.

(2) The "Special rules" and "Critical habitat" columns provide a cross reference to other sections in Parts 17, 222, 226, or 227. The "Special rules" column will also be used to cite the special rules that describe experimental populations and determine if they are essential or nonessential. Separate listing will be made for experimental populations, and the status column will include the following symbols: "XE" for an essential experimental population and "XN" for a nonessential experimental population. The term "NA" (not applicable) appearing in either of these two columns indicates that there are no special rules and/or critical habitat for that par-

ticular species. However, all other appropriate rules in Parts 17, 217 through 227, and 402 still apply to that species. In addition, there may be other rules in this title that relate to such wildlife, e.g., port-of-entry requirements. It is not intended that the references in the "Special rules" column list all the regulations of the two Services which might apply to the species or to the regulations of other Federal agencies or State or local governments.

(g) The listing of a particular taxon includes all lower taxonomic units. For example, the genus *Hylobates* (gibbons) is listed as Endangered throughout its entire range (China, India, and SE Asia); consequently, all species, subspecies, and populations of that genus are considered listed as Endangered for the purposes of the Act. In 1978 (43 FR 6230–6233) the species *Haliaeetus leucocephalus* (bald eagle) was listed as Threatened in "USA (WA, OR, MN, WI, MI)" rather than its entire population; thus, all individuals of the bald eagle found in those five States are considered listed as Threatened for the purposes of the Act.

(h) The "List of Endangered and Threatened Wildlife" is provided below:

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
MAMMALS							
Anoa, lowland	*Bubalus depressicornis* (=*B. anoa depressicornis*).	Indonesia	Entire	E	3	NA	NA
Anoa, mountain	*Bubalus quarlesi* (=*B. anoa quarlesi*)	...do	...do	E	15	NA	NA
Antelope, giant sable	*Hippotragus niger variani*	Angola	...do	E	15	NA	NA
Argali	*Ovis ammon hodgsoni*	China (Tibet, Himalayas)	...do	E	15	NA	NA
Armadillo, giant	*Priodontes maximus* (=*giganteus*)	Venezuela and Guyana to Argentina	...do	E	15	NA	NA
Armadillo, pink fairy	*Chlamyphorus truncatus*	Argentina	...do	E	3	NA	NA
Ass, African wild	*Equus asinus* (=*africanus*)	Somalia, Sudan, Ethiopia	Somalia, Sudan, Ethiopia.	E	3, 22	NA	NA
Ass, Asian wild (=kulan, onager)	*Equus hemionus*	Southwestern and Central Asia	Entire	E	3	NA	NA
Avahi	*Avahi* (=*Lichanotus*) *laniger* (=entire genus).	Malagasy Republic (=Madagascar)	...do	E	3	NA	NA
Aye-Aye	*Daubentonia madagascariensis*	Malagasy Republic (=Madagascar)	...do	E	3	NA	NA
Babirusa	*Babyrousa babyrussa*	Indonesia	...do	E	15	NA	NA
Baboon, gelada	*Theropithecus gelada*	Ethiopia	...do	T	16	NA	17.40(c)
Bandicoot, barred	*Perameles bougainville*	Australia	...do	E	4	NA	NA
Bandicoot, desert	*Perameles eremiana*	...do	...do	E	6	NA	NA
Bandicoot, lesser rabbit	*Macrotis leucura*	...do	...do	E	4	NA	NA
Bandicoot, pig footed	*Chaeropus ecaudatus*	...do	...do	E	4	NA	NA
Bandicoot, rabbit	*Macrotis lagotis*	...do	...do	E	4	NA	NA
Banteng	*Bos javanicus* (=*banteng*)	Southeast Asia	...do	E	3	NA	NA
Bat, Bulmer's fruit (flying fox)	*Aproteles bulmerae*	Papua New Guinea	...do	E	139	NA	NA
Bat, bumblebee	*Craseonycteris thonglongyai*	Thailand	...do	E	139	NA	NA
Bat, gray	*Myotis grisescens*	Central and Southeastern U.S.A.	...do	E	13	NA	NA
Bat, Hawaiian hoary	*Lasiurus cinereus semotus*	U.S.A. (HI)	...do	E	2	NA	NA
Bat, Indiana	*Myotis sodalis*	Eastern and Midwestern U.S.A.	...do	E	1	17.95(a)	NA
Bat, little Mariana fruit	*Pteropus tokudae*	Western Pacific Ocean: U.S.A. (Guam)	...do	E	156	NA	NA
Bat, Mariana fruit	*Pteropus mariannus mariannus*	Western Pacific Ocean: U.S.A. (Guam, Rota, Tinian, Saipan, Agiguan).	Guam	E	156	NA	NA
Bat, Ozark big-eared	*Plecotus townsendii ingens*	U.S.A. (MO, OK, AR)	Entire	E	85	NA	NA
Bat, Rodrigues fruit (flying fox)	*Pteropus rodricensis*	Indian Ocean: Rodrigues Island	...do	E	139	NA	NA
Bat, Singapore roundleaf horseshoe	*Hipposideros ridleyi*	Malaysia	...do	E	139	NA	NA
Bat, Virginia big-eared	*Plecotus townsendii virginianus*	U.S.A. (KY, NC, WV, VA)	...do	E	85	17.95(a)	NA
Bear, Baluchistan	*Ursus thibetanus gedrosianus*	Iran, Pakistan	...do	E	233	NA	NA
Bear, brown	*Ursus arctos pruinosus*	China (Tibet)	Guam	E	15	NA	NA
Bear, brown	*Ursus arctos arctos*	Palearctic	Italy	E	15	NA	NA
Bear, brown or grizzly	*Ursus arctos* (=*U.a. horribilis*)	Holarctic	U.S.A. 48 conterminous States	T	1, 2, 9	NA	17.40(b)
Bear, brown or grizzly	*Ursus arctos* (=*U.a. nelsoni*)	Holarctic	Mexico	E	3	NA	NA
Beaver	*Castor fiber birulai*	Mongolia	Entire	E	15	NA	NA
Bison, wood	*Bison bison athabascae*	Canada, Northwestern U.S.A.	Canada	E	3	NA	NA

Bobcat	*Felis rufus escuinapae*	Central Mexico	Entire	E	15	NA	NA
Bontebok (antelope)	*Damaliscus dorcas dorcas*	South Africa	...do	E	15	NA	NA
Camel, Bactrian	*Camelus bactrianus* (=*ferus*)	Mongolia, China	...do	E	15	NA	NA
Caribou, woodland	*Rangifer tarandus caribou*	Canada, U.S.A. (AK, ID, ME, MI, MN, MT, NH, VT, WA, WI).	Canada (that part of S.E. Brit. Col. bounded by the Can.-USA border,	E	128E, 138E, 143	NA	NA

Bobcat	*Felis rufus escuinapae*	Central Mexico	Entire	E	15	NA	NA
Bontebok (antelope)	*Damaliscus dorcas dorcas*	South Africa	do	E	15	NA	NA
Camel, Bactrian	*Camelus bactrianus (=ferus)*	Mongolia, China	do	E	15	NA	NA
Caribou, woodland	*Rangifer tarandus caribou*	Canada, U.S.A. (AK, ID, ME, MI, MN, MT, NH, VT, WA, WI).	Canada (that part of S.E. Brit. Col. bounded by the Can.-USA border, Columbia R., Kootenay R., Kootenay L., and Kootenai R.), U.S.A. (ID, WA).	E	128E, 136E, 143	NA	NA
Cat, Andean	*Felis jacobita*	Chile, Peru, Bolivia, Argentina	Entire	E	15	NA	NA
Cat, black-footed	*Felis nigripes*	Southern Africa	do	E	15	NA	NA
Cat, flat-headed	*Felis planiceps*	Malaysia, Indonesia	do	E	15	NA	NA
Cat, Iriomote	*Felis (Mayailurus) iriomotensis*	Japan (Iriomote Island, Ryukyu Islands)	do	E	50	NA	NA
Cat, leopard	*Felis bengalensis bengalensis*	India, Southeast Asia	do	E	15	NA	NA
Cat, marbled	*Felis marmorata*	Nepal, Southeast Asia, Indonesia	do	E	15	NA	NA
Cat, Pakistan sand	*Felis margarita scheffeli*	Pakistan	do	E	139	NA	NA
Cat, Temminck's (=golden cat)	*Felis temmincki*	Nepal, China, Southeast Asia, Indonesia (Sumatra).	do	E	15	NA	NA
Cat, tiger	*Felis tigrinus*	Costa Rica to northern Argentina	do	E	5	NA	NA
Chamois, Apennine	*Rupicapra rupicapra ornata*	Italy	do	E	15	NA	NA
Cheetah	*Acinonyx jubatus*	Africa to India	do	E	3, 5	NA	NA
Chimpanzee	*Pan troglodytes*	West and Central Africa	do	T	16	NA	17.40(c)
Chimpanzee, pygmy	*Pan paniscus*	Zaire	do	T	16	NA	17.40(c)
Chinchilla	*Chinchilla brevicaudata boliviana*	Bolivia	do	E	15	NA	NA
Civet, Malabar large-spotted	*Viverra megaspila civettina*	India	do	E	50	NA	NA
Cochito (=Gulf of California harbor porpoise).	*Phocoena sinus*	Mexico (Gulf of California)	do	E	169	NA	NA
Colobus, Preuss's red	*Colobus badius preussi*	Cameroon	do	E	139	NA	NA
Cougar, eastern	*Felis concolor couguar*	Eastern North America	do	E	6	NA	NA
Deer, Bactrian	*Cervus elaphus bactrianus*	U.S.S.R., Afghanistan	do	E	50	NA	NA
Deer, Bawean	*Axis (=Cervus) porcinus kuhli*	Indonesia	do	E	3	NA	NA
Deer, Barbary	*Cervus elaphus barbarus*	Morocco, Tunisia, Algeria	do	E	50	NA	NA
Deer, Cedros Island mule	*Odocoileus hemionus cedrosensis*	Mexico (Cedros Island)	do	E	10	NA	NA
Deer, Columbian white-tailed	*Odocoileus virginianus leucurus*	U.S.A. (WA, OR)	do	E	1	NA	NA
Deer, Corsican red	*Cervus elaphus corsicanus*	Corsica, Sardinia	do	E	50	NA	NA
Deer, Eld's brow-antlered	*Cervus eldi*	India to Southeast Asia	do	E	3	NA	NA
Deer, Formosan sika	*Cervus nippon taiouanus*	Taiwan	do	E	50	NA	NA
Deer, hog	*Axis (=Cervus) porcinus annamiticus*	Thailand, Indochina	do	E	15	NA	NA
Deer, key	*Odocoileus virginianus clavium*	U.S.A. (FL)	do	E	1	NA	NA
Deer, marsh	*Blastocerus dichotomus*	Argentina, Uruguay, Paraguay, Bolivia, Brazil.	do	E	3	NA	NA
Deer, McNeill's	*Cervus elaphus macneilli*	China (Sinkiang, Tibet)	do	E	3	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Deer, musk	*Moschus* spp. (all species)	Central and East Asia	Afghanistan, Bhutan, Burma, China (Tibet, Yunnan), India, Nepal, Pakistan, Sikkim.	E	15	NA	NA
Deer, North China sika	*Cervus nippon mandarinus*	China (Shantung and Chihli Provinces)	Entire	E	50	NA	NA
Deer, pampas	*Ozotoceros bezoarticus*	Brazil, Argentina, Uruguay, Bolivia, Paraguay.	do	E	15	NA	NA
Deer, Persian fallow	*Dama dama mesopotamica*	Iraq, Iran	do	E	3	NA	NA
Deer, Philippine	*Axis* (= *Cervus*) *porcinus calamianensis*	Philippines (Calamian Islands)	do	E	15	NA	NA
Deer, Ryukyu sika	*Cervus nippon keramae*	Japan (Ryukyu Islands)	do	E	50	NA	NA
Deer, Shansi sika	*Cervus nippon grassianus*	China (Shansi Province)	do	E	50	NA	NA
Deer, South China sika	*Cervus nippon kopschi*	Southern China	do	E	50	NA	NA
Deer, swamp (= barasingha)	*Cervus duvauceli*	India, Nepal	do	E	3	NA	NA
Deer, Yarkand	*Cervus elaphus yarkandensis*	China (Sinkiang)	do	E	50	NA	NA
Dhole (= Asiatic wild dog)	*Cuon alpinus*	U.S.S.R., Korea, China, India, Southeast Asia.	do	E	3	NA	NA
Dibbler	*Antechinus apicalis*	Australia	do	E	4	NA	NA
Dog, African wild	*Lycaon pictus*	Sub-Saharan Africa	do	E	139	NA	NA
Drill	*Papio leucophaeus*	Equatorial West Africa	do	E	16	NA	NA
Dugong	*Dugong dugon*	East Africa to southern Japan, including U.S.A. (Trust Territories).	do	E	4	NA	NA
Duiker, Jentink's	*Cephalophus jentinki*	Sierra Leone, Liberia, Ivory Coast	do	E	50	NA	NA
Eland, Western giant	*Taurotragus derbianus derbianus*	Senegal to Ivory Coast	do	E	50	NA	NA
Elephant, African	*Loxodonta africana*	Africa	do	T	40	NA	17.40(e)
Elephant, Asian	*Elephas maximus*	South-central and Southeast Asia	do	E	15	NA	NA
Ferret, black-footed	*Mustela nigripes*	Western U.S.A., Western Canada	do	E	1, 3	NA	NA
Fox, Northern swift	*Vulpes velox hebes*	U.S.A. (northern plains), Canada	Canada	E	3	NA	NA
Fox, San Joaquin kit	*Vulpes macrotis mutica*	U.S.A. (CA)	Entire	E	1	NA	NA
Fox, Simien	*Canis* (*Simenia*) *simensis*	Ethiopia	do	E	50	NA	NA
Gazelle, Clark's (= Dibatag)	*Ammodorcas clarkei*	Somalia, Ethiopia	do	E	3	NA	NA
Gazelle, Cuvier's	*Gazella cuvieri*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Gazelle, Mhorr	*Gazella dama mhorr*	Morocco	do	E	3	NA	NA
Gazelle, Moroccan (= Dorcas)	*Gazella dorcas massaesyla*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Gazelle, Rio de Oro Dama	*Gazella dama lozanoi*	Western Sahara	do	E	3	NA	NA
Gazelle, Arabian	*Gazella gazella*	Arabian Peninsula, Palestine, Sinai	do	E	50	NA	NA
Gazelle, sand	*Gazella subgutturosa marica*	Jordan, Arabian Peninsula	do	E	50	NA	NA
Gazelle, Saudi Arabian	*Gazella dorcas saudiya*	Israel, Iraq, Jordan, Syria, Arabian Peninsula.	do	E	50	NA	NA
Gazelle, Pelzeln's	*Gazella dorcas pelzelni*	Somalia	do	E	50	NA	NA
Gazelle, slender-horned (= Rhim)	*Gazella leptoceros*	Sudan, Egypt, Algeria, Libya	do	E	3	NA	NA
Gibbons	*Hylobates* spp. (including *Nomascus*)	China, India, Southeast Asia	do	E	3, 15	NA	NA

Goat, wild (= Chiltan markhor)	*Capra aegagrus* (= *falconeri chiltanensis*)	Southwestern Asia	Chiltan Range of west-central Pakistan	E	15	NA	NA
Goral	*Nemorhaedus goral*						

Goat, wild (=Chiltan markhor)	*Capra aegagrus* (=*falconeri chiltanensis*)	Southwestern Asia	Chiltan Range of west-central Pakistan.	E	16	NA	NA
Goral	*Nemorhaedus goral*	East Asia	Entire	E	15	NA	NA
Gorilla	*Gorilla gorilla*	Central and Western Africa	do	E	3	NA	NA
Guadalupe fur seal	*Arctocephalus townsendi*	U.S.A. (Farallon Islands of CA) south to Mexico (Islas Revillagigedo).	do	T	212	NA	227.11
Hare, hispid	*Caprolagus hispidus*	India, Nepal, Bhutan	do	E	15	NA	NA
Hartebeest, Swayne's	*Alcelaphus buselaphus swaynei*	Ethiopia, Somalia	do	E	3, 50	NA	NA
Hartebeest, Tora	*Alcelaphus buselaphus tora*	Ethiopia, Sudan, Egypt	do	E	50	NA	NA
Hog, pygmy	*Sus salvanius*	India, Nepal, Bhutan, Sikkim	do	E	3	NA	NA
Horse, Przewalski's	*Equus przewalskii*	Mongolia, China	do	E	15	NA	NA
Huemul, North Andean	*Hippocamelus antisensis*	Ecuador, Peru, Chile, Bolivia, Argentina	do	E	15	NA	NA
Huemul, South Andean	*Hippocamelus bisulcus*	Chile, Argentina	do	E	15	NA	NA
Hutia, Cabrera's	*Capromys angelcabrerai*	Cuba	do	E	233	NA	NA
Hutia, dwarf	*Capromys nana*	do	do	E	233	NA	NA
Hutia, large-eared	*Capromys auritus*	do	do	E	233	NA	NA
Hutia, little earth	*Capromys sanfelipensis*	do	do	E	233	NA	NA
Hyena, Barbary	*Hyaena hyaena barbara*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Hyena, brown	*Hyaena brunnea*	Southern Africa	do	E	3	NA	NA
Ibex, Pyrenean	*Capra pyrenaica pyrenaica*	Spain	do	E	3	NA	NA
Ibex, Walia	*Capra walie*	Ethiopia	do	E	3	NA	NA
Impala, black-faced	*Aepyceros melampus petersi*	Namibia, Angola	do	E	3	NA	NA
Indri	*Indri indri* (=entire genus)	Malagasy Republic (=Madagascar)	do	E	3	NA	NA
Jaguar	*Panthera onca*	U.S.A. (TX, NM, AZ), C. and S. America	Mexico southward	E	6	NA	NA
Jaguarundi	*Felis yagouaroundi cacomitli*	U.S.A. (TX), Mexico	Entire	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi fossata*	Mexico, Nicaragua	do	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi panamensis*	Nicaragua, Costa Rica, Panama	do	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi tolteca*	U.S.A. (AZ), Mexico	do	E	15	NA	NA
Kangaroo, eastern gray	*Macropus giganteus* (all subspecies except *tasmaniensis*).	Australia	do	T	7	NA	17.40(a)
Kangaroo, red	*Macropus (Megaleia) rufus*	do	do	T	7	NA	17.40(a)
Kangaroo, Tasmanian forester	*Macropus giganteus tasmaniensis*	Australia (Tasmania)	do	E	6	NA	NA
Kangaroo, western gray	*Macropus fuliginosus*	Australia	do	T	7	NA	17.40(a)
Kouprey	*Bos sauveli*	Vietnam, Laos, Cambodia, Thailand	do	E	3	NA	NA
Langur, capped	*Presbytis pileata*	India, Burma, Bangladesh	do	E	15	NA	NA
Langur, entellus	*Presbytis entellus*	China (Tibet), India, Pakistan, Kashmir, Sri Lanka, Sikkim, Bangladesh.	do	E	15	NA	NA
Langur, Douc	*Pygathrix nemaeus*	Cambodia, Laos, Vietnam	do	E	3	NA	NA
Langur, Francois'	*Presbytis francoisi*	China (Kwangsi), Indochina	do	E	16	NA	NA
Langur, golden	*Presbytis geei*	India (Assam), Bhutan	do	E	15	NA	NA
Langur, long-tailed	*Presbytis potenziani*	Indonesia	do	T	16	NA	17.40(c)
Langur, Pagi Island	*Nasalis (Simias) concolor*	do	do	E	3	NA	NA
Langur, purple-faced	*Presbytis senex*	Sri Lanka (=Ceylon)	do	T	16	NA	17.40(c)
Langur, Tonkin snub-nosed	*Pygathrix (Rhinopithecus) avunculus*	Vietnam	do	T	16	NA	17.40(c)
Lechwe, red	*Kobus leche*	Southern Africa	do	T	3, 15, 106	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Lemurs	Lemuridae (incl. Cheirogaleidae, Lepilemuridae); all members of genera *Lemur, Phaner, Hapalemur, Lepilemur, Microcebus, Allocebus, Cheirogaleus, Varecia*.	Malagasy Republic (=Madagascar)	...do	E	3, 15	NA	NA
Leopard	*Panthera pardus*	Africa, Asia	Wherever found, except where it is listed as Threatened as set forth below.	E	3, 5, 114	NA	NA
Do	...do	...do	In Africa, in the wild, south of, and including, the following countries: Gabon, Congo, Zaire, Uganda, Kenya.	T	3, 5, 114	NA	17.40(f)
Leopard, clouded	*Neofelis nebulosa*	Southeast and south-central Asia, Taiwan	Entire	E	3, 15	NA	NA
Leopard, snow	*Panthera uncia*	Central Asia	...do	E	5	NA	NA
Linsang, spotted	*Prionodon pardicolor*	Nepal, Assam, Vietnam, Cambodia, Laos, Burma.	...do	E	15	NA	NA
Lion, Asiatic	*Panthera leo persica*	Turkey to India	...do	E	3	NA	NA
Loris, lesser slow	*Nycticebus pygmaeus*	Indochina	...do	T	16	NA	17.40(c)
Lynx, Spanish	*Felis (=Lynx) pardina*	Spain, Portugal	...do	E	3	NA	NA
Macaque, Formosan rock	*Macaca cyclopis*	Taiwan	...do	T	16	NA	17.40(c)
Macaque, Japanese	*Macaca fuscata*	Japan (Shikoku, Kyushu and Honshu Islands).	...do	T	16	NA	17.40(c)
Macaque, lion-tailed	*Macaca silenus*	India	...do	E	3	NA	NA
Macaque, stump-tailed	*Macaca arctoides*	India (Assam) to southern China	...do	T	16	NA	17.40(c)
Macaque, Toque	*Macaca sinica*	Sri Lanka (=Ceylon)	...do	T	16	NA	17.40(c)
Manatee, Amazonian	*Trichechus inunguis*	South America (Amazon River Basin)	...do	E	3	NA	NA
Manatee, West African	*Trichechus senegalensis*	West Coast of Africa from Senegal River to Cuanza River.	...do	T	52	NA	NA
Manatee, West Indian (Florida)	*Trichechus manatus*	U.S.A. (southeastern), Caribbean Sea, South America.	...do	E	1, 3	17.95(a)	NA
Mandrill	*Papio sphinx*	Equatorial West Africa	...do	E	16	NA	NA
Mangabey, Tana River	*Cercocebus galeritus*	Kenya	...do	E	3	NA	NA
Mangabey, white-collared	*Cercocebus torquatus*	Senegal to Ghana; Nigeria to Gabon	...do	E	16	NA	NA
Margay	*Felis wiedii*	U.S.A. (TX), C. and S. America	Mexico southward	E	5	NA	NA
Markhor, Kabal	*Capra falconeri megaceros*	Afghanistan, Pakistan	Entire	E	15	NA	NA
Markhor, straight-horned	*Capra falconeri jerdoni*	...do	...do	E	15	NA	NA
Marmoset, buff headed	*Callithrix flaviceps*	Brazil	...do	E	139	NA	NA

Marmoset, buffy tufted-ear	*Callithrix jacchus aurita*	...do	...do	E	233	NA	NA
Marmoset, cotton-top	*Saguinus oedipus*	Costa Rica to Colombia	...do	E	16	NA	NA
Marmoset, Goeldi's	*Callimico goeldii*	Brazil, Colombia, Ecuador, Peru, Bolivia	...do	E	3	NA	NA
Marmot, Vancouver Island	*Marmota vancouverensis*	Canada (Vancouver Island)	...do	E	139	[illegible]	[illegible]
Marsupial, eastern jerboa	*Antechinomys laniger*	Australia	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Marsupial mouse, [illegible]	[illegible]	[illegible]					

Markhor, Kabul	*Capra falconeri megaceros*	Afghanistan, Pakistan	Entire	E	15	NA	
Markhor, straight-horned	*Capra falconeri jerdoni*	....do	....do	E	15	NA	
Marmoset, buff-headed	*Callithrix flaviceps*	Brazil	....do	E	139	NA	

Marmoset, buffy tufted-ear	*Callithrix jacchus aurita*	....do	....do	E	233	NA	NA
Marmoset, cotton-top	*Saguinus oedipus*	Costa Rica to Colombia	....do	E	16	NA	NA
Marmoset, Goeldi's	*Callimico goeldii*	Brazil, Colombia, Ecuador, Peru, Bolivia	....do	E	3	NA	NA
Marmot, Vancouver Island	*Marmota vancouverensis*	Canada (Vancouver Island)	....do	E	139	NA	NA
Marsupial, eastern jerboa	*Antechinomys laniger*	Australia	....do	E	4	NA	NA
Marsupial-mouse, large desert	*Sminthopsis psammophila*	....do	....do	E	4	NA	NA
Marsupial-mouse, long-tailed	*Sminthopsis longicaudata*	....do	....do	E	4	NA	NA
Marten, Formosan yellow-throated	*Martes flavigula chrysospila*	Taiwan	....do	E	3	NA	NA
Monkey, black colobus	*Colobus satanas*	Equatorial Guinea, People's Republic of Congo, Cameroon, Gabon.	....do	E	16	NA	NA
Monkey, black howler	*Alouatta pigra*	Mexico, Guatemala, Belize	....do	T	16	NA	17.40(c)
Monkey Diana	*Cercopithecus diana*	Coastal West Africa	....do	E	16	NA	NA
Monkey, howler	*Alouatta palliata* (=*villosa*)	Mexico to South America	....do	E	15	NA	NA
Monkey, L'hoest's	*Cercopithecus lhoesti*	Upper Eastern Congo Basin, Cameroon	....do	E	16	NA	NA
Monkey, Preuss' red colobus	*Colobus badius preussi*	Cameroon	....do	E	139	NA	NA
Monkey, proboscis	*Nasalis larvatus*	Borneo	....do	E	15	NA	NA
Monkey, red-backed squirrel	*Saimiri oerstedii*	Costa Rica, Panama	....do	E	3	NA	NA
Monkey, red bellied	*Cercopithecus erythrogaster*	Western Nigeria	....do	E	16	NA	NA
Monkey, red-eared nose-spotted	*Cercopithecus erythrotis*	Nigeria, Cameroon, Fernando Po	....do	E	16	NA	NA
Monkey, spider	*Ateles geoffroyi frontatus*	Costa Rica, Nicaragua	....do	E	3	NA	NA
Monkey, spider	*Ateles geoffroyi panamensis*	Costa Rica, Panama	....do	E	3	NA	NA
Monkey, Tana River red colobus	*Colobus rufomitratus* (=*badius*) *rufomitratus*.	Kenya	....do	E	3, 16	NA	NA
Monkey, woolly spider	*Brachyteles arachnoides*	Brazil	....do	E	3	NA	NA
Monkey, yellow-tailed woolly	*Lagothrix flavicauda*	Andes of northern Peru	....do	E	16	NA	NA
Monkey, Zanzibar red colobus	*Colobus kirki*	Tanzania	....do	E	3	NA	NA
Mouse, Alabama beach	*Peromyscus polionotus ammobates*	U.S.A. (AL)	....do	E	183	17.95(a)	NA
Mouse, Australian native	*Zyzomys* (=*Notomys*) *pedunculatus*	Australia	....do	E	15	NA	NA
Mouse, Australian native	*Notomys aquilo*	....do	....do	E	15	NA	NA
Mouse, Choctawhatchee beach	*Peromyscus polionotus allophrys*	U.S.A. (FL)	....do	E	183	17.95(a)	NA
Mouse, Field's	*Pseudomys fieldi*	Australia	....do	E	4	NA	NA
Mouse, Gould's	*Pseudomys gouldii*	....do	....do	E	6	NA	NA
Mouse, Key Largo cotton	*Peromyscus gossypinus allapaticola*	U.S.A. (FL)	....do	E	131E, 160	NA	NA
Mouse, New Holland	*Pseudomys novaehollandiae*	Australia	....do	E	4	NA	NA
Mouse, Perdido Key beach	*Peromyscus polionotus trissyllepsis*	U.S.A. (AL, FL)	....do	E	183	17.95(a)	NA
Mouse, salt marsh harvest	*Reithrodontomys raviventris*	U.S.A. (CA)	....do	E	2	NA	NA
Mouse, Shark Bay	*Pseudomys praeconis*	Australia	....do	E	4	NA	NA
Mouse, Shortridge's	*Pseudomys shortridgei*	....do	....do	E	4	NA	NA
Mouse, Smoky	*Pseudomys fumeus*	....do	....do	E	4	NA	NA
Mouse, western	*Pseudomys occidentalis*	....do	....do	E	4	NA	NA
Muntjac, Fea's	*Muntiacus feae*	Northern Thailand, Burma	....do	E	50	NA	NA
Native-cat, eastern	*Dasyurus viverrinus*	Australia	....do	E	6	NA	NA
Numbat	*Myrmecobius fasciatus*	....do	....do	E	4, 6	NA	NA
Ocelot	*Felis pardalis*	U.S.A. (AZ, TX) to C. and S. America	....do	E	6, 119	NA	NA
Orangutan	*Pongo pygmaeus*	Borneo, Sumatra	....do	E	3	NA	NA
Oryx, Arabian	*Oryx leucoryx*	Arabian Peninsula	....do	E	3	NA	NA
Otter, Cameroon clawless	*Aonyx* (*Paraonyx*) *congica microdon*	Cameroon, Nigeria	....do	E	3	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Otter, giant	*Pteronura brasiliensis*	South America	do	E	3	NA	NA
Otter, long-tailed	*Lutra longicaudis* (incl. *platensis*)	do	do	E	3, 15	NA	NA
Otter, marine	*Lutra felina*	Peru south to Straits of Magellan	do	E	15	NA	NA
Otter, southern river	*Lutra provocax*	Chile, Argentina	do	E	15	NA	NA
Otter, southern sea	*Enhydra lutris nereis*	West coast U.S.A. (WA, OR, CA) south to Mexico (Baja California).	do	T	21	NA	NA
Panda, giant	*Ailuropoda melanoleuca*	People's Republic of China	do	E	139	NA	NA
Pangolin (=scaly anteater)	*Manis temmincki*	Africa	do	E	15	NA	NA
Panther, Florida	*Felis concolor coryi*	U.S.A. (LA and AR east to SC and FL)	do	E	1	NA	NA
Planigale, little	*Planigale ingrami subtilissima* (formerly *P. subtilissima*).	Australia	do	E	4	NA	NA
Planigale, southern	*Planigale tenuirostris*	do	do	E	4	NA	NA
Porcupine, thin-spined	*Chaetomys subspinosus*	Brazil	do	E	3	NA	NA
Possum, Leadbeater's	*Gymnobelideus leadbeateri*	do	do	E	233	NA	NA
Possum, mountain pygmy	*Burramys parvus*	Australia	do	E	4	NA	NA
Possum, scaly-tailed	*Wyulda squamicaudata*	do	do	E	4	NA	NA
Prairie dog, Mexican	*Cynomys mexicanus*	Mexico	do	E	3	NA	NA
Prairie dog, Utah	*Cynomys parvidens*	U.S.A. (UT)	do	T	6, 149	NA	17.40(g)
Pronghorn, peninsular	*Antilocapra americana peninsularis*	Mexico (Baja California)	do	E	10	NA	NA
Pronghorn, Sonoran	*Antilocapra americana sonoriensis*	U.S.A. (AZ), Mexico	do	E	1, 3	NA	NA
Pudu	*Pudu pudu*	Southern South America	do	E	15	NA	NA
Puma, Costa Rican	*Felis concolor costaricensis*	Nicaragua, Panama, Costa Rica	do	E	15	NA	NA
Quokka	*Setonix brachyurus*	Australia	do	E	6	NA	NA
Rabbit, Ryukyu	*Pentalagus furnessi*	Japan (Ryukyu Islands)	do	E	50	NA	NA
Rabbit, volcano	*Romerolagus diazi*	Mexico	do	E	3	NA	NA
Rat, false water	*Xeromys myoides*	Australia	do	E	4	NA	NA
Rat, Fresno kangaroo	*Dipodomys nitratoides exilis*	U.S.A. (CA)	do	E	170	17.95(a)	NA
Rat, Morro Bay kangaroo	*Dipodomys heermanni morroensis*	do	do	E	2	17.95(a)	NA
Rat, stick-nest	*Leporillus conditor*	Australia	do	E	6	NA	NA
Rat-kangaroo, brush-tailed	*Bettongia penicillata*	do	do	E	4	NA	NA
Rat-kangaroo, Gaimard's	*Bettongia gaimardi*	do	do	E	6	NA	NA
Rat-kangaroo, Lesuer's	*Bettongia lesueur*	do	do	E	4	NA	NA
Rat-kangaroo, plain	*Caloprymnus campestris*	do	do	E	4	NA	NA
Rat-kangaroo, Queensland	*Bettongia tropica*	do	do	E	4	NA	NA
Rhinoceros, black	*Diceros bicornis*	Sub-Saharan Africa	do	E	97	NA	NA
Rhinoceros, great Indian	*Rhinoceros unicornis*	India, Nepal	do	E	4	NA	NA
Rhinoceros, Javan	*Rhinoceros sondaicus*	Indonesia, Indochina, Burma, Thailand, Sikkim, Bangladesh, Malaysia.	do	E	3	NA	NA
Rhinoceros, northern white	*Ceratotherium simum cottoni*	Zaire, Sudan, Uganda, Central African Republic.	do	E	3	NA	NA
Rhinoceros, Sumatran	*Dicerorhinus* (=*Didermoceros*) *sumatrensis*.	Bangladesh to Vietnam to Indonesia (Borneo).	do	E	3	NA	NA
Saiga, Mongolian (antelope)	*Saiga tatarica mongolica*	Mongolia	do	E	15	NA	NA
Saki, southern bearded	*Chiropotes satanas satanas*	Brazil	do	E	233	NA	NA
Saki, white-nosed	*Chiropotes albinasus*	do	do	E	3	NA	NA
Seal, Caribbean monk	*Monachus tropicalis*	Caribbean Sea, Gulf of Mexico	do	E	1, 2, 45	NA	NA
Seal, Hawaiian monk	*Monachus schauinslandi*	U.S.A. (HI)	do	E	18	NA	NA
Seal, Mediterranean monk	*Monachus monachus*	Mediterranean, Northwest African Coast and Black Sea.	do	E	3	NA	NA
Seladang (=Gaur)	*Bos gaurus*	Bangladesh, Southeast Asia, India	do	E	3	NA	NA
Serow	*Capricornis sumatraensis*	East Asia, Sumatra	do	[illegible]	[illegible]		
Serval, Barbary	*Felis serval constantina*	[illegible]					

[illegible]

Saki, southern bearded	*Chiropotes satanas satanas*	Brazil	do	E	233	NA	NA
Saki, white-nosed	*Chiropotes albinasus*	do	do	E	3	NA	NA
Seal, Caribbean monk	*Monachus tropicalis*	Caribbean Sea, Gulf of Mexico	do	E	1, 2, 45	NA	NA
Seal, Hawaiian monk	*Monachus schauinslandi*	U.S.A. (HI)	do	E	16	NA	NA
Seal, Mediterranean monk	*Monachus monachus*	Mediterranean, Northwest African Coast and Black Sea	do	E	3	NA	NA
Seladang (=Gaur)	*Bos gaurus*	Bangladesh, Southeast Asia, India	do	E	3	NA	NA
Serow	*Capricornis sumatraensis*	East Asia, Sumatra	do	E	16	NA	NA
Serval, Barbary	*Felis serval constantina*	Algeria	do	E	3	NA	NA
Shapo	*Ovis vignei vignei*	Kashmir	do	E	15	NA	NA
Shou	*Cervus elaphus wallichi*	Tibet, Bhutan	do	E	3	NA	NA
Shrew, Dismal Swamp southeastern	*Sorex longirostris fisheri*	U.S.A. (VA, NC)	do	T	246	NA	NA
Siamang	*Symphalangus syndactylus*	Malaysia, Indonesia	do	E	15	NA	NA
Sifakas	*Propithecus* spp. (all species)	Malagasy Republic (=Madagascar)	do	E	4	NA	NA
Sloth, Brazilian three-toed	*Bradypus torquatus*	Brazil	do	E	3, 4	NA	NA
Solenodon, Cuban	*Solenodon (Atopogale) cubanus*	Cuba	do	E	3	NA	NA
Solenodon, Haitian	*Solenodon paradoxus*	Dominican Republic, Haiti	do	E	3	NA	NA
Squirrel, Carolina northern flying	*Glaucomys sabrinus coloratus*	U.S.A. (NC, TN)	do	E	189	NA	NA
Squirrel, Delmarva Peninsula fox	*Sciurus niger cinereus*	U.S.A. (Delmarva Peninsula to southeast PA).	Entire, except Sussex Co., DE.	E	1, 161, 166	NA	NA
Do	do	do	U.S.A. (DE—Sussex County).	XN	161	NA	17.84(a)
Squirrel, Virginia northern flying	*Glaucomys sabrinus fuscus*	U.S.A. (VA, WV)	Entire	E	189	NA	NA
Stag, Barbary	*Cervus elaphus barbarus*	Tunisia, Algeria	do	E	3	NA	NA
Stag, Kashmir	*Cervus elaphus hanglu*	Kashmir	do	E	3	NA	NA
Suni, Zanzibar	*Neotragus (Nesotragus) moschatus moschatus*	Zanzibar (and nearby islands)	do	E	50	NA	NA
Tahr, Arabian	*Hemitragus jayakari*	Oman	do	E	50	NA	NA
Tamaraw	*Bubalus mindorensis*	Philippines	do	E	4	NA	NA
Tamarin, golden-rumped (=golden-headed Tamarin; =golden-lion Marmoset).	*Leontopithecus (=Leontideus)* spp. (all species).	Brazil	do	E	3	NA	NA
Tamarin, pied	*Saguinus bicolor*	do	do	E	16	NA	NA
Tamarin, white-footed	*Saguinus leucopus*	Colombia	do	T	16	NA	17.40(c)
Tapir, Asian	*Tapirus indicus*	Burma, Laos, Cambodia, Vietnam, Malaysia, Indonesia, Thailand	do	E	15	NA	NA
Tapir, Brazilian	*Tapirus terrestris*	Colombia and Venezuela south to Paraguay and Argentina	do	E	3	NA	NA
Tapir, Central American	*Tapirus bairdi*	Southern Mexico to Colombia and Ecuador.	do	E	3	NA	NA
Tapir, mountain	*Tapirus pinchaque*	Colombia, Ecuador and possibly Peru and Venezuela.	do	E	3	NA	NA
Tarsier, Philippine	*Tarsius syrichta*	Philippines	do	T	16	NA	17.40(c)
Tiger	*Panthera tigris*	Temperate and Tropical Asia	do	E	3, 5	NA	NA
Tiger, Tasmanian (=Thylacine)	*Thylacinus cynocephalus*	Australia	do	E	3	NA	NA
Uakari (all species)	*Cacajao* spp. (all species)	Peru, Brazil, Ecuador, Colombia, Venezuela.	do	E	3	NA	NA
Urial	*Ovis musimon (=orientalis) ophion*	Cyprus	do	E	15	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Vicuna	*Vicugna vicugna*	South America (Andes)	....do	E	3	NA	NA
Vole, Amargosa	*Microtus californicus scirpensis*	U.S.A. (CA)	....do	E	166	17.95(a)	NA
Wallaby, banded hare	*Lagostrophus fasciatus*	Australia	....do	E	4	NA	NA
Wallaby, brindled nail-tailed	*Onychogalea fraenata*	....do	....do	E	4	NA	NA
Wallaby, crescent nail-tailed	*Onychogalea lunata*	....do	....do	E	4	NA	NA
Wallaby, Parma	*Macropus parma*	....do	....do	E	4	NA	NA
Wallaby, Western hare	*Lagorchestes hirsutus*	....do	....do	E	4	NA	NA
Wallaby, yellow-footed rock	*Petrogale xanthopus*	....do	....do	E	6	NA	NA
Whale, blue	*Balaenoptera musculus*	Oceanic	....do	E	3	NA	NA
Whale, bowhead	*Balaena mysticetus*	Oceanic (north latitudes only)	....do	E	3	NA	NA
Whale, finback	*Balaenoptera physalus*	Oceanic	....do	E	3	NA	NA
Whale, gray	*Eschrichtius robustus*	North Pacific Ocean: coastal and Bering Sea	....do	E	3	NA	NA
Whale, humpback	*Megaptera novaeangliae*	Oceanic	....do	E	3	NA	NA
Whale, right	*Balaena glacialis*	....do	....do	E	3	NA	NA
Whale, Sei	*Balaenoptera borealis*	....do	....do	E	3	NA	NA
Whale, sperm	*Physeter catodon*	....do	....do	E	3	NA	NA
Wolf, gray	*Canis lupus*	Holarctic	U.S.A. (48 conterminous States, except MN), Mexico.	E	1, 6, 13, 15, 35	17.95(a)	NA
Do	....do	....do	U.S.A. (MN)	T	35	17.95(a)	17.40(d)
Wolf, maned	*Chrysocyon brachyurus*	Argentina, Bolivia, Brazil, Paraguay, Uruguay.	Entire	E	4	NA	NA
Wolf, red	*Canis rufus*	U.S.A. (southeastern U.S.A. west to central TX).	....do	E	1	NA	NA
Wombat, hairy-nosed (=Barnard's and Queensland hairy-nosed).	*Lasiorhinus krefftii* (formerly *L. barnardi* and *L. gillespiei*).	Australia	....do	E	4, 6	NA	NA
Woodrat, Key Largo	*Neotoma floridana smalli*	U.S.A. (FL)	....do	E	131E, 160	NA	NA
Yak, wild	*Bos grunniens*	China (Tibet), India	....do	E	3	NA	NA
Zebra, Grevy's	*Equus grevyi*	Kenya, Ethiopia, Somalia	....do	T	54	NA	NA
Zebra, Hartmann's mountain	*Equus zebra hartmannae*	Namibia, Angola	....do	T	54, 111	NA	NA
Zebra, mountain	*Equus zebra zebra*	South Africa	....do	E	15, 111	NA	NA
BIRDS							
Akepa, Hawaii (honeycreeper)	*Loxops coccineus coccineus*	U.S.A. (HI)	....do	E	2	NA	NA
Akepa, Maui (honeycreeper)	*Loxops coccineus ochraceus*	....do	....do	E	2	NA	NA
Akialoa, Kauai (honeycreeper)	*Hemignathus procerus*	....do	....do	E	1	NA	NA
Akiapolaau (honeycreeper)	*Hemignathus munroi* (=*wilsoni*)	....do	....do	E	1	NA	NA
Albatross, short-tailed	*Diomedea albatrus*	North Pacific Ocean: Japan, U.S.S.R., U.S.A. (AK, CA, HI, OR, WA).	Entire, except U.S.A.	E	3	NA	NA
Blackbird, yellow-shouldered	*Agelaius xanthomus*	U.S.A. (PR)	Entire	E	17	17.95(b)	NA
Bobwhite, masked (quail)	*Colinus virginianus ridgwayi*	U.S.A. (AZ), Mexico (Sonora)	....do	E	1, 3	NA	NA
Booby, Abbott's	*Sula abbotti*	Indian Ocean: Christmas Island	....do	E	15	NA	NA
Bristlebird, western	*Dasyornis brachypterus longirostris*	Australia	....do	E	3	NA	NA
Bristlebird, western rufous	*Dasyornis broadbenti litoralis*	....do	....do	E	15	NA	NA
Broadbill, Guam	*Myiagra freycineti*	Western Pacific Ocean: U.S.A. (Guam)	....do	E	156	NA	NA
Bulbul, Mauritius olivaceous	*Hypsipetes borbonicus olivaceus*	Indian Ocean: Mauritius	....do	E	3	NA	NA
Bullfinch, Sao Miguel (finch)	*Pyrrhula pyrrhula murina*	Eastern Atlantic Ocean: Azores	....do	E	[illegible]	[illegible]	[illegible]
Bushwren, New Zealand	*Xenicus* [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Bobwhite, masked (quail)	*Colinus virginianus ridgwayi*	U.S.A. (AZ), Mexico (Sonora)	do	E	1, 3	NA	NA
Booby, Abbott's	*Sula abbotti*	Indian Ocean: Christmas Island	do	E	15	NA	NA
Bristlebird, western	*Dasyornis brachypterus longirostris*	Australia	do	E	3	NA	NA
Bristlebird, western rufous	*Dasyornis broadbenti litoralis*	do	do	E	15	NA	NA
Broadbill, Guam	*Myiagra freycineti*	Western Pacific Ocean: U.S.A. (Guam)	do	E	156	NA	NA
Bulbul, Mauritius olivaceous	*Hypsipetes borbonicus olivaceus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Bullfinch, Sao Miguel (finch)	*Pyrrhula pyrrhula murina*	Eastern Atlantic Ocean: Azores	do	E	3	NA	NA
Bushwren, New Zealand	*Xenicus longipes*	New Zealand	do	E	3	NA	NA
Bustard, great Indian	*Choriotis nigriceps*	India, Pakistan	do	E	3	NA	NA
Cahow (=Bermuda Petrel)	*Pterodroma cahow*	North Atlantic Ocean: Bermuda	do	E	3	NA	NA
Condor, Andean	*Vultur gryphus*	Colombia to Chile and Argentina	do	E	4	NA	NA
Condor, California	*Gymnogyps californianus*	U.S.A. (OR, CA), Mexico (Baja California)	do	E	1	17.95(b)	NA
Coot, Hawaiian (=alae keo keo)	*Fulica americana alai*	U.S.A. (HI)	do	E	2	NA	NA
Cotinga, banded	*Cotinga maculata*	Brazil	do	E	15	NA	NA
Cotinga, white-winged	*Xipholena atropurpurea*	do	do	E	15	NA	NA
Crane, black-necked	*Grus nigricollis*	China (Tibet)	do	E	15	NA	NA
Crane, Cuba sandhill	*Grus canadensis nesiotes*	West Indies: Cuba	do	E	15	NA	NA
Crane, hooded	*Grus monacha*	Japan, U.S.S.R.	do	E	4	NA	NA
Crane, Japanese	*Grus japonensis*	China, Japan, Korea, U.S.S.R.	do	E	3	NA	NA
Crane, Mississippi sandhill	*Grus canadensis pulla*	U.S.A. (MS)	do	E	8	17.95(b)	NA
Crane, Siberian white	*Grus leucogeranus*	U.S.S.R. (Siberia) to India, including Iran and China.	do	E	4	NA	NA
Crane, white-naped	*Grus vipio*	Mongolia	do	E	15	NA	NA
Crane, whooping	*Grus americana*	Canada, U.S.A. (Rocky Mountains east to Carolinas), Mexico.	do	E	1, 3	17.95(b)	NA
Creeper, Hawaii	*Oreomystis (=Loxops) mana*	U.S.A. (HI)	do	E	10	NA	NA
Creeper, Molokai (=kakawahie)	*Paroreomyza (=Oreomystis, =Loxops) flammea.*	do	do	E	2	NA	NA
Creeper, Oahu (=alauwahio)	*Paroreomyza (=Oreomystis, =Loxops) maculata.*	do	do	E	2	NA	NA
Crow, Hawaiian (='alala)	*Corvus hawaiiensis (=tropicus)*	do	do	E	1	NA	NA
Crow, Mariana	*Corvus kubaryi*	Western Pacific Ocean: U.S.A. (Guam, Rota).	do	E	158	NA	NA
Cuckoo-shrike, Mauritius	*Coquus (=Coracina) typicus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Cuckoo-shrike, Reunion	*Coquus (=Coracina) newtoni*	Indian Ocean: Reunion	do	E	3	NA	NA
Curassow, razor-billed	*Mitu (=Crax) mitu mitu*	Brazil (Eastern)	do	E	15	NA	NA
Curassow, red-billed	*Crax blumenbachii*	Brazil	do	E	4	NA	NA
Curassow, Trinidad white-headed	*Pipile pipile pipile*	West Indies: Trinidad	do	E	3	NA	NA
Curlew, Eskimo	*Numenius borealis*	Alaska and northern Canada to Argentina	do	E	1, 3	NA	NA
Dove, cloven-feathered	*Drepanoptila holosericea*	Southwest Pacific Ocean: New Caledonia	do	E	3	NA	NA
Dove, Grenada gray-fronted	*Leptotila rufaxilla wellsi*	West Indies: Grenada	do	E	3	NA	NA
Duck, Hawaiian (=koloa)	*Anas wyvilliana*	U.S.A. (HI)	do	E	1	NA	NA
Duck, Laysan	*Anas laysanensis*	do	do	E	1	NA	NA
Duck, pink-headed	*Rhodonessa caryophyllacea*	India	do	E	15	NA	NA
Duck, white-winged wood	*Cairina scutulata*	India, Malaysia, Indonesia, Thailand	do	E	3	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Eagle, bald	*Haliaeetus leucocephalus*	North America south to northern Mexico	U.S.A. (conterminous States, except WA, OR, MN, WI, MI).	E	1, 34	NA	NA
Do	....do	....do	U.S.A. (WA, OR, MN, WI, MI).	T	34	NA	17.41(a)
Eagle, Greenland white-tailed	*Haliaeetus albicilla groenlandicus*	Greenland and adjacent Atlantic islands	....do	E	15	NA	NA
Eagle, harpy	*Harpia harpyja*	Mexico south to Argentina	....do	E	15	NA	NA
Eagle, Philippine (=monkey-eating)	*Pithecophaga jefferyi*	Philippines	....do	E	3	NA	NA
Eagle, Spanish imperial	*Aquila heliaca adalberti*	Spain, Morocco, Algeria	Entire	E	3	NA	NA
Egret, Chinese	*Egretta eulophotes*	China, Korea	....do	E	3	NA	NA
Falcon, American peregrine	*Falco peregrinus anatum*	Nests from central Alaska across north-central Canada to central Mexico, winters south to South America.	....do	E	2, 3, 145	17.95(b)	NA
Falcon, Arctic peregrine	*Falco peregrinus tundrius*	Nests from northern Alaska to Greenland; winters south to Central and South America	....do	T	2, 3, 145	NA	NA
Falcon, Eurasian peregrine	*Falco peregrinus peregrinus*	Europe, Eurasia south to Africa and Mideast	....do	E	15	NA	NA
Falcon, northern aplomado	*Falco femoralis septentrionalis*	U.S.A. (AZ, NM, TX), Mexico, Guatemala	....do	E	210	NA	NA
Falcon, peregrine	*Falco peregrinus*	Worldwide, except Antarctica and most Pacific Islands	Wherever found in wild in the conterminous 48 States.	E(S/A)	145	NA	NA
Finch, Laysan (honeycreeper)	*Telespyza (=Psittirostra) cantans*	U.S.A. (HI)	Entire	E	1	NA	NA
Finch, Nihoa (honeycreeper)	*Telespyza (=Psittirostra) ultima*	....do	....do	E	1	NA	NA
Flycatcher, Euler's	*Empidonax euleri johnstonei*	West Indies: Grenada	....do	E	3	NA	NA
Flycatcher, Seychelles paradise	*Terpsiphone corvina*	Indian Ocean: Seychelles	....do	E	3	NA	NA
Flycatcher, Tahiti	*Pomarea nigra*	South Pacific Ocean: Tahiti	....do	E	3	NA	NA
Fody, Seychelles (weaver-finch)	*Foudia sechellarum*	Indian Ocean: Seychelles	....do	E	3	NA	NA
Frigatebird, Andrew's	*Fregata andrewsi*	East Indian Ocean	....do	E	15	NA	NA
Goose, Aleutian Canada	*Branta canadensis leucopareia*	U.S.A. (AK, CA, OR, WA), Japan	....do	E	1, 3	NA	NA
Goose, Hawaiian (=nene)	*Nesochen (=Branta) sandvicensis*	U.S.A. (HI)	....do	E	1	NA	NA
Goshawk, Christmas Island	*Accipiter fasciatus natalis*	Indian Ocean: Christmas Island	....do	E	3	NA	NA
Grackle, slender-billed	*Quiscalus (=Cassidix) palustris*	Mexico	....do	E	3	NA	NA
Grasswren, Eyrean (flycatcher)	*Amytornis goyderi*	Australia	....do	E	3	NA	NA
Grebe, Atitlan	*Podilymbus gigas*	Guatemala	....do	E	3	NA	NA
Greenshank, Nordmann's	*Tringa guttifer*	U.S.S.R., Japan, south to Malaya, Borneo	....do	E	15	NA	NA
Guan, horned	*Oreophasis derbianus*	Guatemala, Mexico	....do	E	3	NA	NA
Gull, Audouin's	*Larus audouinii*	Mediterranean Sea	....do	E	3	NA	NA
Gull, relict	*Larus relictus*	India, China	....do	E	15	NA	NA
Hawk, Anjouan Island sparrow	*Accipiter francesii pusillus*	Indian Ocean: Comoro Islands	....do	E	3	NA	NA

Hawk, Galapagos	*Buteo galapagoensis*	Ecuador (Galapagos Islands)	....do	E	3	NA	NA
Hawk, Hawaiian (=io)	*Buteo solitarius*	U.S.A. (HI)	....do	E	1	NA	NA
Hermit, hook-billed (hummingbird)	*Glaucis (=Ramphodon) dohrnii*	Brazil	....do	E	15	NA	NA
Honeycreeper, crested (='akohekohe)	*Palmeria dolei*	U.S.A. (HI)	....do	E	1	NA	NA
Hornbill, helmeted	*Rhinoplax vigil*	Thailand, Malaysia	....do	E	15	NA	NA
Honeyeater, helmeted	*Meliphaga cassidix*	Australia	....do	E	4	NA	NA
Ibis, Japanese crested	*Nipponia nippon*	China, Japan, U.S.S.R., Korea	....do	E	3	NA	NA
Kagu	*Rhynochetos jubatus*	South Pacific Ocean: New Caledonia	....do				

Gull, relict	*Larus relictus*	India, China	do	E	15	NA	NA
Hawk, Anjouan Island sparrow	*Accipiter francesii pusillus*	Indian Ocean: Comoro Islands	do	E	3	NA	NA
Hawk, Galapagos	*Buteo galapagoensis*	Ecuador (Galapagos Islands)	do	E	3	NA	NA
Hawk, Hawaiian (=io)	*Buteo solitarius*	U.S.A. (HI)	do	E	1	NA	NA
Hermit, hook-billed (hummingbird)	*Glaucis (=Ramphodon) dohrnii*	Brazil	do	E	15	NA	NA
Honeycreeper, crested (='akohekohe)	*Palmeria dolei*	U.S.A. (HI)	do	E	1	NA	NA
Hornbill, helmeted	*Rhinoplax vigil*	Thailand, Malaysia	do	E	15	NA	NA
Honeyeater, helmeted	*Meliphaga cassidix*	Australia	do	E	4	NA	NA
Ibis, Japanese crested	*Nipponia nippon*	China; Japan, U.S.S.R., Korea	do	E	3	NA	NA
Kagu	*Rhynochetos jubatus*	South Pacific Ocean: New Caledonia	do	E	3	NA	NA
Kakapo (=owl-parrot)	*Strigops habroptilus*	New Zealand	do	E	3	NA	NA
Kestrel, Mauritius	*Falco punctatus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Kestrel, Seychelles	*Falco araea*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Kingfisher, Guam Micronesian	*Halcyon cinnamomina cinnamomina*	Western Pacific Ocean: U.S.A. (Guam)	do	E	156	NA	NA
Kite, Cuba hook-billed	*Chondrohierax uncinatus wilsonii*	West Indies: Cuba	do	E	3	NA	NA
Kite, Everglade snail	*Rostrhamus sociabilis plumbeus*	U.S.A. (FL), Cuba	Florida	E	1	17.95(b)	NA
Kite, Grenada hook-billed	*Chondrohierax uncinatus mirus*	West Indies: Grenada	Entire	E	3	NA	NA
Kokako (wattlebird)	*Callaeas cinerea*	New Zealand	do	E	3	NA	NA
Macaw, glaucous	*Anodorhynchus glaucus*	Paraguay, Uruguay, Brazil	do	E	15	NA	NA
Macaw, indigo	*Anodorhynchus leari*	Brazil	do	E	15	NA	NA
Macaw, little blue	*Cyanopsitta spixii*	do	do	E	15	NA	NA
Magpie-robin, Seychelles (thrush)	*Copsychus sechellarum*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Malkoha, red-faced (cuckoo)	*Phaenicophaeus pyrrhocephalus*	Sri Lanka (=Ceylon)	do	E	3	NA	NA
Mallard, Mariana	*Anas oustaleti*	West Pacific Ocean: U.S.A. (Guam, Mariana Islands).	do	E	23	NA	NA
Megapode, Micronesian (=La Perouse's)	*Megapodius laperouse*	West Pacific Ocean: U.S.A. (Palau Island, Mariana Islands).	do	E	3	NA	NA
Megapode, Maleo	*Macrocephalon maleo*	Indonesia (Celebes)	do	E	3	NA	NA
Millerbird, Nihoa (old world warbler)	*Acrocephalus familiaris kingi*	U.S.A. (HI)	do	E	1	NA	NA
Monarch, Tinian (old world flycatcher)	*Monarcha takatsukasae*	Western Pacific Ocean: U.S.A. (Mariana Islands)	do	E	3	NA	NA
Moorhen (=gallinule), Hawaiian common	*Gallinula chloropus sandvicensis*	U.S.A. (HI)	do	E	1	NA	NA
Moorhen (=gallinule), Mariana common	*Gallinula chloropus guami*	Western Pacific Ocean: U.S.A. (Guam, Tinian, Saipan, Pagan).	do	E	156	NA	NA
Nightjar (=whip-poor-will), Puerto Rico	*Caprimulgus noctitherus*	U.S.A. (PR)	do	E	6	NA	NA
Nukupu'u (honeycreeper)	*Hemignathus lucidus*	U.S.A. (HI)	do	E	1, 2	NA	NA
'O'o, Kauai (='O'o 'A'a) (honeyeater)	*Moho braccatus*	do	do	E	1	NA	NA
Ostrich, Arabian	*Struthio camelus syriacus*	Jordan, Saudi Arabia	do	E	3	NA	NA
Ostrich, West African	*Struthio camelus spatzi*	Spanish Sahara	do	E	3	NA	NA
'O'u (honeycreeper)	*Psittirostra psittacea*	U.S.A. (HI)	do	E	1	NA	NA
Owl, Anjouan scops	*Otus rutilus capnodes*	Indian Ocean: Comoro Island	do	E	3	NA	NA
Owl, giant scops	*Otus gurneyi*	Philippines: Marinduque and Mindanao Island	do	E	15	NA	NA
Owl, Seychelles	*Otus insularis*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Owlet, Morden's (=Sokoke)	*Otus ireneae*	Kenya	do	E	3	NA	NA
Palila (honeycreeper)	*Loxioides (=Psittirostra) bailleui*	U.S.A. (HI)	do	E	1	17.95(b)	NA
Parakeet, Forbes'	*Cyanoramphus auriceps forbesi*	New Zealand	do	E	3, 15	NA	NA
Parakeet, golden	*Aratinga guarouba*	Brazil	do	E	4	NA	NA
Parakeet, golden-shouldered (=hooded)	*Psephotus chrysopterygius*	Australia	do	E	3	NA	NA
Parakeet, Mauritius	*Psittacula echo*	Indian Ocean: Mauritius	do	E	3	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Parakeet, ochre-marked	*Pyrrhura cruentata*	Brazil	...do	E	3	NA	NA
Parakeet, orange-bellied	*Neophema chrysogaster*	Australia	...do	E	4	NA	NA
Parakeet, paradise (=beautiful)	*Psephotus pulcherrimus*	...do	...do	E	4	NA	NA
Parakeet, scarlet-chested (=splendid)	*Neophema splendida*	...do	...do	E	4	NA	NA
Parakeet, turquoise	*Neophema pulchella*	...do	...do	E	3	NA	NA
Parrot, Australian	*Geopsittacus occidentalis*	...do	...do	E	3	NA	NA
Parrot, Bahaman or Cuban	*Amazona leucocephala*	West Indies: Cuba, Bahamas, Caymans	...do	E	3, 15	NA	NA
Parrot, ground	*Pezoporus wallicus*	Australia	...do	E	6	NA	NA
Parrot, imperial	*Amazona imperialis*	West Indies: Dominica	...do	E	3	NA	NA
Parrot, Puerto Rican	*Amazona vittata*	U.S.A. (PR)	...do	E	1	NA	NA
Parrot, red browed	*Amazona rhodocorytha*	Brazil	...do	E	3	NA	NA
Parrot, red-capped	*Pionopsitta pileata*	...do	...do	E	15	NA	NA
Parrot, red-necked	*Amazona arausiaca*	West Indies: Dominica	...do	E	50	NA	NA
Parrot, red-spectacled	*Amazona pretrei pretrei*	Brazil, Argentina	...do	E	15	NA	NA
Parrot, St. Lucia	*Amazona versicolor*	West Indies: St. Lucia	...do	E	3	NA	NA
Parrot, St. Vincent	*Amazona guildingii*	West Indies: St. Vincent	...do	E	3	NA	NA
Parrot, thick-billed	*Rhynchopsitta pachyrhyncha*	Mexico, U.S.A. (AZ, NM)	Mexico	E	3	NA	NA
Parrot, vinaceous-breasted	*Amazona vinacea*	Brazil	Entire	E	15	NA	NA
Parrotbill, Maui (honeycreeper)	*Pseudonestor xanthophrys*	U.S.A. (HI)	...do	E	1	NA	NA
Pelican, brown	*Pelecanus occidentalis*	U.S.A. (Carolinas to TX, CA), West Indies, C. and S. America: Coastal.	Entire, except U.S. Atlantic coast, FL, AL.	E	2, 3, 171	NA	NA
Penguin, Galapagos	*Spheniscus mendiculus*	Ecuador (Galapagos Islands)	Entire	E	3	NA	NA
Petrel, Hawaiian dark-rumped	*Pterodroma phaeopygia sandwichensis*	U.S.A. (HI)	...do	E	2, 4, 1	NA	NA
Pheasant, bar-tailed	*Syrmaticus humiae*	Burma, China	...do	E	3	NA	NA
Pheasant, Blyth's tragopan	*Tragopan blythii*	Burma, China, India	...do	E	3	NA	NA
Pheasant, brown eared	*Crossoptilon mantchuricum*	China	...do	E	3	NA	NA
Pheasant, Cabot's tragopan	*Tragopan caboti*	...do	...do	E	3	NA	NA
Pheasant, Chinese monal	*Lophophorus lhuysii*	...do	...do	E	3	NA	NA
Pheasant, Edward's	*Lophura edwardsi*	Vietnam	...do	E	3	NA	NA
Pheasant, Elliot's	*Syrmaticus ellioti*	China	...do	E	15	NA	NA
Pheasant, imperial	*Lophura imperialis*	Vietnam	...do	E	3	NA	NA
Pheasant, Mikado	*Syrmaticus mikado*	Taiwan	...do	E	3	NA	NA
Pheasant, Palawan peacock	*Polyplectron emphanum*	Philippines	...do	E	3	NA	NA
Pheasant, Sclater's monal	*Lophophorus sclateri*	Burma, China, India	...do	E	3	NA	NA
Pheasant, Swinhoe's	*Lophura swinhoii*	Taiwan	...do	E	3	NA	NA
Pheasant, western tragopan	*Tragopan melanocephalus*	India, Pakistan	...do	E	3	NA	NA
Pheasant, white eared	*Crossoptilon crossoptilon*	China (Tibet), India	...do	E	4	NA	NA
Pigeon, Azores wood	*Columba palumbus azorica*	East Atlantic Ocean: Azores	...do	E	3	NA	NA
Pigeon, Chatham Island	*Hemiphaga novaeseelandiae chathamensis*	New Zealand	...do	E	3	NA	NA
Pigeon, Mindoro zone-tailed	*Ducula mindorensis*	Philippines	...do	E	16	NA	NA
Pigeon, Puerto Rican plain	*Columba inornata wetmorei*	U.S.A. (PR)	...do	E	2	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Piping guan, black-fronted	*Pipile jacutinga*	Argentina	...do	E	15	NA	NA
Pitta, Koch's	*Pitta kochi*	Philippines	...do	E	15	NA	NA
Plover, New Zealand shore	*Thinornis novaeseelandiae*	New Zealand	...do	E	3	NA	NA
Plover, piping	*Charadrius melodus*	USA (Great Lakes, northern Great Plains, Atlantic and Gulf [illegible]	Great Lakes	E	211	[illegible]	

Pigeon, Mindoro zone-tailed	*Ducula mindorensis*	Philippines	do	E	15	NA	NA
Pigeon, Puerto Rican plain	*Columba inornata wetmorei*	U.S.A. (PR)	do	E	2	NA	NA
Piping-guan, black-fronted	*Pipile jacutinga*	Argentina	do	E	15	NA	NA
Pitta, Koch's	*Pitta kochi*	Philippines	do	E	15	NA	NA
Plover, New Zealand shore	*Thinornis novaeseelandiae*	New Zealand	do	E	3	NA	NA
Plover, piping	*Charadrius melodus*	U.S.A. (Great Lakes, northern Great Plains, Atlantic and Gulf coasts, PR VI), Canada, Mexico, Bahamas, West Indies.	Great Lakes watershed in States of IL, IN, MI, MN, NY, OH, PA, and WI and Province of Ontario.	E	211	NA	NA
Do	do	do	Entire, except those areas where listed as endangered above.	T	211	NA	NA
Po'ouli (honeycreeper)	*Melamprosops phaeosoma*	U.S.A. (HI)	Entire	E	10	NA	NA
Prairie-chicken, Attwater's greater	*Tympanuchus cupido attwateri*	U.S.A. (TX)	do	E	1	NA	NA
Quail, Merriam's Montezuma	*Cyrtonyx montezumae merriami*	Mexico (Vera Cruz)	do	E	15	NA	NA
Quetzal, resplendent	*Pharomachrus mocinno*	Mexico to Panama	do	E	15	NA	NA
Rail, Auckland Island	*Rallus pectoralis muelleri*	New Zealand	do	E	3	NA	NA
Rail, California clapper	*Rallus longirostris obsoletus*	U.S.A. (CA)	do	E	2	NA	NA
Rail, Guam	*Rallus owstoni*	Western Pacific Ocean: U.S.A. (Guam)	do	E	146E, 156	NA	NA
Rail, light-footed clapper	*Rallus longirostris levipes*	U.S.A. (CA), Mexico (Baja California)	do	E	2	NA	NA
Rail, Lord Howe wood	*Tricholimnas sylvestris*	Australia (Lord Howe Island)	do	E	15	NA	NA
Rail, Yuma clapper	*Rallus longirostris yumanensis*	Mexico, U.S.A. (AZ, CA)	do	E	1	NA	NA
Rhea, Darwin's	*Pterocnemia pennata*	Argentina, Bolivia, Peru, Uruguay	do	E	3	NA	NA
Robin, Chatham Island	*Petroica traversi*	New Zealand	do	E	3	NA	NA
Robin, scarlet-breasted (flycatcher)	*Petroica multicolor multicolor*	Australia (Norfolk Island)	do	E	3	NA	NA
Rockfowl, grey-necked	*Picathartes oreas*	Cameroon, Gabon	do	E	3	NA	NA
Rockfowl, white-necked	*Picathartes gymnocephalus*	Africa: Togo to Sierra Leone	do	E	3	NA	NA
Roller, long-tailed ground	*Uratelornis chimaera*	Malagasy Republic (=Madagascar)	do	E	3	NA	NA
Scrub-bird, noisy	*Atrichornis clamosus*	Australia	do	E	3	NA	NA
Shama, Cebu black (thrush)	*Copsychus niger cebuensis*	Philippines	do	E	3	NA	NA
Shearwater, Newell's Townsend's (formerly Manx) (='A'o).	*Puffinus auricularis* (formerly *puffinus*) *newelli*.	U.S.A. (HI)	do	T	10	NA	NA
Shrike, San Clemente loggerhead	*Lanius ludovicianus mearnsi*	U.S.A. (CA)	do	E	28	NA	NA
Siskin, red	*Carduelis* (= *Spinus*) *cucullata*	South America	do	E	15	NA	NA
Sparrow, Cape Sable seaside	*Ammodramus* (= *Ammospiza*) *maritimus mirabilis*.	U.S.A. (FL)	do	E	1	17.95(b)	NA
Sparrow, dusky seaside	*Ammodramus* (= *Ammospiza*) *maritimus nigrescens*.	do	do	E	1	17.95(b)	NA
Sparrow, Florida grasshopper	*Ammodramus savannarum floridanus*	do	do	E	239	NA	NA
Sparrow, San Clemente sage	*Amphispiza belli clementeae*	U.S.A. (CA)	do	T	28	NA	NA
Starling, Ponape mountain	*Aplonis pelzelni*	West Pacific Ocean: U.S.A. (Caroline Islands).	do	E	3	NA	NA
Starling, Rothschild's (myna)	*Leucopsar rothschildi*	Indonesia (Bali)	do	E	3	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Stilt, Hawaiian (=Ae'o)	*Himantopus mexicanus (=himantopus) knudseni.*	U.S.A. (Hawaii)	...do	E	2	NA	NA
Stork, oriental white	*Ciconia ciconia boyciana*	China, Japan, Korea, U.S.S.R.	...do	E	3	NA	NA
Stork, wood	*Mycteria americana*	U.S.A., (CA, AZ, TX, to Carolinas), Mexico, Central and South America.	U.S.A. (AL, FL, GA, SC).	E	142	NA	NA
Swiftlet, Mariana gray (=Vanikoro)	*Aerodramus (=Collocalia) vanikorensis bartschi.*	Western Pacific Ocean: U.S.A. (Guam, Rota, Tinian, Saipan, Agiguan).	Entire	E	156	NA	NA
Teal, Campbell Island flightless	*Anas aucklandica nesiotis*	New Zealand (Campbell Island)	...do	E	15	NA	NA
Tern, California least	*Sterna antillarum (=albifrons) browni*	Mexico, U.S.A. (CA)	...do	E	2, 3	NA	NA
Tern, least	*Sterna antillarum*	U.S.A. (Atlantic and Gulf coasts, Miss. R. Basin, CA), Gr. and Lesser Antilles, Bahamas, Mexico; winters C. America, northern S. America.	U.S.A. [AR, CO, IA, IL, IN, KS, KY, LA (Miss. R. and tribs. N of Baton Rouge), MS (Miss. R.), MO, MT, NE, NM, ND, OK, SD, TN, TX (Except within 50 miles of coast)].	E	182	NA	NA
Thrasher, white-breasted	*Ramphocinclus brachyurus*	West Indies: St. Lucia, Martinique	Entire	E	3	NA	NA
Thrush, large Kauai	*Myadestes (=Phaeornis) myadestinus*	U.S.A. (HI)	...do	E	2	NA	NA
Thrush, Molokai (=oloma'o)	*Myadestes (=Phaeornis) lanaiensis (=obscurus) rutha*	...do	...do	E	2	NA	NA
Thrush, New Zealand (wattlebird)	*Turnagra capensis*	New Zealand	...do	E	3	NA	NA
Thrush, small Kauai (=puaiohi)	*Myadestes (=Phaeornis) palmeri*	U.S.A. (HI)	...do	E	1	NA	NA
Tinamou, solitary	*Tinamus solitarius*	Brazil, Paraguay, Argentina	...do	E	15	NA	NA
Trembler, Martinique (thrasher)	*Cinclocerthia ruficauda gutturalis*	West Indies: Martinique	...do	E	3	NA	NA
Vireo, least Bell's	*Vireo bellii pusillus*	U.S.A. (CA), Mexico	...do	E	228	NA	NA
Wanderer, plain (collared-hemipode)	*Pedionomous torquatus*	Australia	...do	E	6	NA	NA
Warbler (wood), Bachman's	*Vermivora bachmanii*	U.S.A. (Southeastern), Cuba	...do	E	1, 3	NA	NA
Warbler (wood), Barbados yellow	*Dendroica petechia petechia*	West Indies: Barbados	...do	E	3	NA	NA
Warbler (wood), Kirtland's	*Dendroica kirtlandii*	U.S.A. (principally MI), Canada, West Indies: Bahama Islands.	...do	E	1, 3	NA	NA
Warbler (willow), nightingale reed	*Acrocephalus luscinia*	Western Pacific Ocean	U.S.A. (Mariana Islands).	E	3, 4	NA	NA
Warbler (willow), Rodrigues	*Bebrornis rodericanus*	Mauritius (Rodrigues Islands)	Entire	E	3	NA	NA
Warbler (wood), Semper's	*Leucopeza semperi*	West Indies: St. Lucia	...do	E	3	NA	NA
Warbler (willow), Seychelles	*Bebrornis sechellensis*	Indian Ocean: Seychelles Island	...do	E	3	NA	NA
Whipbird, Western	*Psophodes nigrogularis*	Australia	...do	E	3	NA	NA
White-eye, bridled	*Zosterops conspicillata conspicillata*	Western Pacific Ocean: U.S.A. (Guam)	...do	E	156	NA	NA
White-eye, Norfolk Island	*Zosterops albogularis*	Indian Ocean: Norfolk Islands	...do	E	15	NA	NA
White-eye, Ponape greater	*Rukia longirostra (=sanfordi)*	West Pacific Ocean: U.S.A. (Caroline Islands).	...do	E	3	NA	NA
White eye, Seychelles	*Zosterops modesta*	Indian Ocean: Seychelles	...do	E	3	NA	NA
Woodpecker, imperial	*Campephilus imperialis*	Mexico	...do	E	3	NA	NA
Woodpecker, ivory-billed	*Campephilus principalis*	U.S.A. (southcentral and southeastern), Cuba.	...do	E	1, 3	NA	NA
Woodpecker, red-cockaded	*Picoides (=Dendrocopos) borealis*	U.S.A. (southcentral and southeastern)	...do	E	2	NA	NA
Woodpecker, Tristam's	*Dryocopus javensis richardsi*	Korea	...do	E	3	NA	NA
Wren, Guadaloupe house	*Troglodytes aedon guadeloupensis*	West Indies: Guadeloupe	...do	E	3	NA	NA
Wren, St. Lucia house	*Troglodytes aedon mesoleucus*	West Indies: St. Lucia	...do	E	3	NA	NA

REPTILES

White-eye, Norfolk Island	Zosterops albogularis		do	E	3	NA	NA
White-eye, Ponape greater	Rukia longirostra (=sanfordi)	Pacific Ocean: U.S.A. (Caroline Islands)					
White-eye, Seychelles	*Zosterops modesta*	Indian Ocean: Seychelles	do	E	3	NA	NA
Woodpecker, imperial	*Campephilus imperialis*	Mexico	do	E	3	NA	NA
Woodpecker, ivory-billed	*Campephilus principalis*	U.S.A. (southcentral and southeastern), Cuba.	do	E	1, 3	NA	NA
Woodpecker, red-cockaded	*Picoides (=Dendrocopos) borealis*	U.S.A. (southcentral and southeastern)	do	E	2	NA	NA
Woodpecker, Tristam's	*Dryocopus javensis richardsi*	Korea	do	E	3	NA	NA
Wren, Guadeloupe house	*Troglodytes aedon guadeloupensis*	West Indies: Guadeloupe	do	E	3	NA	NA
Wren, St. Lucia house	*Troglodytes aedon mesoleucus*	West Indies: St. Lucia	do	E	3	NA	NA
REPTILES							
Alligator, American	*Alligator mississippiensis*	Southeastern U.S.A.	Wherever found in wild except those areas where listed as threatened as set forth below	E	1, 11, 51, 60, 113, 134, 186	NA	NA
Do	do	do	U.S.A. (certain areas of GA and SC, as set forth in 17.42(a)(1)). 17.42(a)(1)).	T	20, 47, 51, 60, 134, 186	NA	17.42(a)
Do	do	do	U.S.A. (FL, LA and TX); in captivity wherever found	T(S/A)	11, 47, 51, 60, 113, 134, 186	NA	17.42(a)
Alligator, Chinese	*Alligator sinensis*	China	Entire	E	15	NA	NA
Anole, Culebra Island giant	*Anolis roosevelti*	U.S.A. (PR: Culebra Island)	do	E	25	17.95(c)	NA
Boa, Jamaican	*Epicrates subflavus*	Jamaica	do	E	3	NA	NA
Boa, Mona	*Epicrates monensis monensis*	U.S.A. (PR)	do	T	33	17.95(c)	NA
Boa, Puerto Rico	*Epicrates inornatus*	do	do	E	2	NA	NA
Boa, Round Island (no common name)	*Casarea dussumieri*	Indian Ocean: Mauritius	do	E	88	NA	NA
Boa, Round Island (no common name)	*Bolyeria multocarinata*	do	do	E	88	NA	NA
Boa, Virgin Islands tree	*Epicrates monensis granti*	U.S. and British Virgin Islands	do	E	2, 86	NA	NA
Caiman, Apaporis River	*Caiman crocodilus apaporiensis*	Colombia	do	E	15	NA	NA
Caiman, black	*Melanosuchus niger*	Amazon basin	do	E	15	NA	NA
Caiman, broad-snouted	*Caiman latirostris*	Brazil, Argentina, Paraguay, Uruguay	do	E	15	NA	NA
Caiman, Yacare	*Caiman crocodilus yacare*	Bolivia, Argentina, Peru, Brazil	do	E	3	NA	NA
Chuckwalla, San Esteban Island	*Sauromalus varius*	Mexico	do	E	88	NA	NA
Crocodile, African dwarf	*Osteolaemus tetraspis tetraspis*	West Africa	do	E	15	NA	NA
Crocodile, African slender-snouted	*Crocodylus cataphractus*	Western and central Africa	do	E	5	NA	NA
Crocodile, American	*Crocodylus acutus*	U.S.A. (FL), Mexico, South America, Central America, Caribbean.	do	E	10, 87	17.95(c)	NA
Crocodile, Ceylon mugger	*Crocodylus palustris kimbula*	Sri Lanka	do	E	15	NA	NA
Crocodile, Congo dwarf	*Osteolaemus tetraspis osborni*	Congo River drainage	do	E	15	NA	NA
Crocodile, Cuban	*Crocodylus rhombifer*	Cuba	do	E	3	NA	NA
Crocodile, Morelet's	*Crocodylus moreletii*	Mexico, Belize, Guatemala	do	E	3	NA	NA
Crocodile, mugger	*Crocodylus palustris palustris*	India, Pakistan, Iran, Bangladesh	do	E	15	NA	NA
Crocodile, Nile	*Crocodylus niloticus*	Africa	do	E	3	NA	NA

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Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Crocodile, Orinoco	*Crocodylus intermedius*	South America: Orinoco River Basin	....do	E	3	NA	NA
Crocodile, Philippine	*Crocodylus novaeguineae mindorensis*	Philippine Islands	....do	E	15	NA	NA
Crocodile, saltwater (=estuarine)	*Crocodylus porosus*	Southeast Asia, Australia, Papua-New Guinea, Pacific Islands.	Entire, except Papua-New Guinea	E	87	NA	NA
Crocodile, Siamese	*Crocodylus siamensis*	Southeast Asia, Malay Peninsula	Entire	E	15	NA	NA
Gavial (=gharial)	*Gavialis gangeticus*	Pakistan, Burma, Bangladesh, India, Nepal.	....do	E	3, 15	NA	NA
Gecko, day	*Phelsuma edwardnewtoni*	Indian Ocean: Mauritius	....do	E	3	NA	NA
Gecko, Monito	*Sphaerodactylus micropithecus*	U.S.A. (PR)	....do	E	125	17.95(c)	NA
Gecko, Round Island day	*Phelsuma guentheri*	Indian Ocean: Mauritius	....do	E	3	NA	NA
Gecko, Serpent Island	*Cyrtodactylus serpensinsula*	....do	....do	T	129	NA	NA
Iguana, Acklins ground	*Cyclura nleyi nuchalis*	West Indies: Bahamas	....do	T	129	NA	NA
Iguana, Allen's Cay	*Cyclura cychlura inornata*	....do	....do	T	129	NA	NA
Iguana, Andros Island ground	*Cyclura cychlura cychlura*	....do	....do	T	129	NA	NA
Iguana, Anegada ground	*Cyclura pinguis*	West Indies: British Virgin Islands (Anegada Island).	....do	E	3	NA	NA
Iguana, Barrington land	*Conolophus pallidus*	Ecuador (Galapagos Islands)	....do	E	3	NA	NA
Iguana, Cayman Brac ground	*Cyclura nubila caymanensis*	West Indies: Cayman Islands	....do	T	129	NA	NA
Iguana, Cuban ground	*Cyclura nubila nubila*	Cuba	Entire (excluding population introduced in Puerto Rico).	T	129	NA	NA
Iguana, Exuma Island	*Cyclura cychlura figginsi*	West Indies: Bahamas	Entire	T	129	NA	NA
Iguana, Fiji banded	*Brachylophus fasciatus*	Pacific: Fiji, Tonga	....do	E	88	NA	NA
Iguana, Fiji crested	*Brachylophus vitiensis*	Pacific: Fiji	....do	E	88	NA	NA
Iguana, Grand Cayman ground	*Cyclura nubila lewisi*	West Indies: Cayman Islands	....do	E	129	NA	NA
Iguana, Jamaican	*Cyclura collei*	West Indies: Jamaica	....do	E	129	NA	NA
Iguana, Mayaguana	*Cyclura carinata bartschi*	West Indies: Bahamas	....do	T	129	NA	NA
Iguana, Mona ground	*Cyclura stejnegeri*	U.S.A. (PR: Mona Island)	....do	T	33	17.95(c)	NA
Iguana, Turks and Caicos	*Cyclura carinata carinata*	West Indies: Turks and Caicos Islands	....do	T	129	NA	NA
Iguana, Watling Island ground	*Cyclura nleyi nleyi*	West Indies: Bahamas	....do	E	129	NA	NA
Iguana, White Cay ground	*Cyclura nleyi cristata*	....do	....do	T	129	NA	NA
Lizard, blunt-nosed leopard	*Gambelia (=Crotaphytus) silus*	U.S.A. (CA)	....do	E	1	NA	NA
Lizard, Coachella Valley fringe-toed	*Uma inornata*	....do	....do	T	105	17.95(c)	NA
Lizard, Hierro giant	*Gallotia simonyi simonyi*	Spain (Canary Islands)	....do	E	144	NA	NA
Lizard, Ibiza wall	*Podarcis pityusensis*	Spain (Balearic Islands)	....do	T	144	NA	NA
Lizard, Island night	*Xantusia (=Klauberina) riversiana*	U.S.A. (CA)	....do	T	26	NA	NA
Lizard, St. Croix ground	*Ameiva polops*	U.S.A. (VI)	....do	E	24	17.95(c)	NA
Monitor, Bengal	*Varanus bengalensis*	Iran, Iraq, India, Sri Lanka, Malaysia, Afghanistan, Burma, Vietnam, Thailand.	....do	E	15	NA	NA

Monitor, desert	*Varanus griseus*	North Africa to Nearest, Caspian Sea through U.S.S.R. to Pakistan, Northwest India	....do	E	15	NA	NA

Monitor, desert	*Varanus griseus*	North Africa to Neareast, Caspian Sea through U.S.S.R. to Pakistan, Northwest India.	...do	E	15	NA	NA
Monitor, Komodo island	*Varanus komodoensis*	Indonesia (Komodo, Rinija, Padar, and western Florus Island).	...do	E	15	NA	NA
Monitor, yellow	*Varanus flavescens*	West Pakistan through India to Bangladesh.	...do	E	15	NA	NA
Python, Indian	*Python molurus molurus*	Sri Lanka and India	...do	E	15	NA	NA
Rattlesnake, Aruba island	*Crotalus unicolor*	Aruba Island (Netherland Antilles)	...do	T	129	NA	NA
Rattlesnake, New Mexican ridge-nosed	*Crotalus willardi obscurus*	U.S.A. (NM), Mexico	...do	T	43	17.95(c)	NA
Skink, Round Island	*Leiolopisma telfairi*	Indian Ocean: Mauritius	...do	T	129	NA	NA
Snake, Atlantic salt marsh	*Nerodia fasciata taeniata*	U.S.A. (FL)	...do	T	30	NA	NA
Snake, Concho water	*Nerodia harteri paucimaculata*	U.S.A. (TX)	...do	T	241	NA	NA
Snake, eastern indigo	*Drymarchon corais couperi*	U.S.A. (AL, FL, GA, MS, SC)	...do	T	32	NA	NA
Snake, San Francisco garter	*Thamnophis sirtalis tetrataenia*	U.S.A. (CA)	...do	E	1	NA	NA
Tartaruga	*Podocnemis expansa*	South America: Orinoco and Amazon River basins.	...do	E	3	NA	NA
Terrapin, river (=Tuntong)	*Batagur baska*	Malaysia, Bangladesh, Burma, India, Indonesia	...do	E	3	NA	NA
Tomistoma	*Tomistoma schlegeli*	Malaysia, Indonesia	...do	E	15	NA	NA
Tortoise, angulated	*Geochelone yniphora*	Malagasy Republic (=Madagascar)	...do	E	15	NA	NA
Tortoise, Bolson	*Gopherus flavomarginatus*	Mexico	...do	E	46	NA	NA
Tortoise, desert	*Xerobates (=Scaptochelys, =Gopherus) agassizii.*	U.S.A. (UT, AZ, CA, NV); Mexico	Beaver Dam Slope, Utah.	T	103	17.95(c)	NA
Tortoise, Galapagos	*Geochelone elephantopus*	Ecuador (Galapagos Islands)	Entire	E	3	NA	NA
Tortoise, radiated	*Geochelone (=Testudo) radiata*	Malagasy Republic (=Madagascar)	...do	E	3	NA	NA
Tracaja	*Podocnemis unifilis*	South America: Orinoco and Amazon River basins.	...do	E	3	NA	NA
Tuatara	*Sphenodon punctatus*	New Zealand	...do	E	3	NA	NA
Turtle, aquatic box	*Terrapene coahuila*	Mexico	...do	E	6	NA	NA
Turtle, black softshell	*Trionyx nigricans*	Bangladesh	...do	E	15	NA	NA
Turtle, Burmese peacock	*Morenia ocellata*	Burma	...do	E	15	NA	NA
Turtle, Central American river	*Dermatemys mawii*	Mexico, Belize, Guatemala	...do	E	129	NA	NA
Turtle, Cuatro Cienegas softshell	*Trionyx ater*	Mexico	...do	E	15	NA	NA
Turtle, geometric	*Psammobates geometricus (=Geochelone geometrica).*	South Africa	...do	E	15	NA	NA
Turtle, green sea	*Chelonia mydas*	Circumglobal in tropical and temperate seas and oceans.	Wherever found except where listed as endangered below.	T	2, 42	NA	17.42(b) and Parts 220 and 227.
Do	...do	...do	Breeding colony populations in FL and on Pacific coast of Mexico.	E	2, 42	NA	NA
Turtle, hawksbill sea (=carey)	*Eretmochelys imbricata*	Tropical seas	Entire	E	3	17.95(c)	NA
Turtle, Indian sawback	*Kachuga tecta tecta*	India	...do	E	15	NA	NA
Turtle, Indian softshell	*Trionyx gangeticus*	Pakistan, India	...do	E	15	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Turtle, Kemp's (=Atlantic) Ridley sea	*Lepidochelys kempii*	Tropical and temperate seas in Atlantic Basin.	do	E	4	NA	NA
Turtle, leatherback sea	*Dermochelys coriacea*	Tropical, temperate, and subpolar seas	do	E	3	17.95(c), 226.71	NA
Turtle, loggerhead sea	*Caretta caretta*	Circumglobal in tropical and temperate seas and oceans.	do	T	42	NA	17.42(b) and Parts 220 and 227.
Turtle, Olive (Pacific) Ridley sea	*Lepidochelys olivacea*	Tropical and temperate seas in Pacific Basin.	Wherever found except where listed as endangered below.	T	42	NA	17.42(b) and Parts 220 and 227.
Do	do	do	Breeding colony populations on Pacific coast of Mexico.	E	42	NA	NA
Turtle, peacock softshell	*Trionyx hurum*	India, Bangladesh	Entire	E	15	NA	NA
Turtle, Plymouth red-bellied	*Pseudemys (=Chrysemys) rubriventris bangsi.*	U.S.A. (MA)	do	E	90	17.95(c)	NA
Turtle, short-necked or western swamp	*Pseudemydura umbrina*	Australia	do	E	3	NA	NA
Turtle, spotted pond	*Geoclemys (=Damonia) hamiltonii*	North India, Pakistan	do	E	15	NA	NA
Turtle, three keeled Asian	*Melanochelys (=Geoemyda, Nicoria) tricarinata.*	Central India to Bangladesh and Burma	do	E	15	NA	NA
Viper, Lar Valley	*Vipera latifii*	Iran	do	E	129	NA	NA
AMPHIBIANS							
Coqui, golden	*Eleutherodactylus jasperi*	U.S.A. (PR)	do	T	29	17.95(d)	NA
Frog, Israel painted	*Discoglossus nigriventer*	Israel	do	E	3	NA	NA
Frog, Panamanian golden	*Atelopus varius zeteki*	Panama	do	E	15	NA	NA
Frog, Stephen Island	*Leiopelma hamiltoni*	New Zealand	do	E	3	NA	NA
Salamander, Chinese giant	*Andrias davidianus davidianus*	Western China	do	E	15	NA	NA
Salamander, desert slender	*Batrachoseps aridus*	U.S.A. (CA)	do	E	6	NA	NA
Salamander, Japanese giant	*Andrias davidianus japonicus*	Japan	do	E	15	NA	NA
Salamander, Red Hills	*Phaeognathus hubrichti*	U.S.A. (AL)	do	T	19	NA	NA
Salamander, San Marcos	*Eurycea nana*	U.S.A. (TX)	do	T	98	17.95(d)	17.43(a)
Salamander, Santa Cruz long-toed	*Ambystoma macrodactylum croceum*	U.S.A. (CA)	do	E	1	NA	NA
Salamander, Texas blind	*Typhlomolge rathbuni*	U.S.A. (TX)	do	E	1	NA	NA
Toad, African viviparous	*Nectophrynoides spp.*	Tanzania, Guinea, Ivory Coast, Cameroon, Liberia, Ethiopia.	do	E	15	NA	NA
Toad, Cameroon	*Bufo superciliaris*	Equatorial Africa	do	E	15	NA	NA
Toad, Houston	*Bufo houstonensis*	U.S.A. (TX)	do	E	2	17.95(d)	NA
Toad, Monte Verde	*Bufo periglenes*	Costa Rica	do	E	15	NA	NA
Toad, Wyoming	*Bufo hemiophrys baxteri*	U.S.A. (WY)	do	E	138	NA	NA
FISHES							
Ala Balik (trout)	*Salmo platycephalus*	Turkey	Entire	E	3	NA	NA
Ayumodoki (loach)	*Hymenophysa (=Botia) curta*	Japan	do	E	3	NA	NA
Blindcat, Mexican (catfish)	*Prietella phreatophila*	Mexico	do	[illegible]			
Bonytongue, Asian	*Scleropages form[illegible]*						

Toad, Wyoming	*Bufo hemiophrys baxteri*	U.S.A. (WY)	......do	E	138	NA	NA
FISHES							
Ala Balik (trout)	*Salmo platycephalus*	Turkey	Entire	E	3	NA	NA
Ayumodoki (loach)	*Hymenophysa (=Botia) curta*	Japan	......do	E	3	NA	NA
Blindcat, Mexican (catfish)	*Prietella phreatophila*	Mexico	......do	E	3	NA	NA
Bonytoungue, Asian	*Scleropages formosus*	Thailand, Indonesia, Malaysia	......do	E	15	NA	NA
Catfish (no common name)	*Pangasius sanitwongsei*	Thailand	......do	E	3	NA	NA
Catfish, giant	*Pangasianodon gigas*	......do	......do	E	3	NA	NA
Catfish, Yaqui	*Ictalurus pricei*	U.S.A. (AZ), Mexico	......do	T	157	17.95(e)	17.44(g)
Cavefish, Alabama	*Speoplatyrhinus poulsoni*	U.S.A. (AL)	......do	T	28	17.95(e)	NA
Cavefish, Ozark	*Amblyopsis rosae*	U.S.A. (AR, MO, OK)	......do	T	164	NA	NA
Chub, bonytail	*Gila elegans*	U.S.A. (AZ, CA, CO, NV, UT, WY)	......do	E	92	NA	NA
Chub, Borax Lake	*Gila boraxobius*	U.S.A. (OR)	......do	E	124	17.95(e)	NA
Chub, Chihuahua	*Gila nigrescens*	U.S.A. (NM), Mexico (Chihuahua)	......do	T	132	NA	17.44(g)
Chub, humpback	*Gila cypha*	U.S.A. (AZ, CO, UT, WY)	......do	E	1	NA	NA
Chub, Hutton tui	*Gila bicolor ssp*	U.S.A. (OR)	......do	T	174	NA	17.44(j)
Chub, Mohave tui	*Gila bicolor mohavensis*	U.S.A. (CA)	......do	E	2	NA	NA
Chub, Owens tui	*Gila bicolor snyderi*	......do	......do	E	195	17.95(e)	NA
Chub, Pahranagat roundtail	*Gila robusta jordani*	U.S.A. (NV)	......do	E	2	NA	NA
Chub, slender	*Hybopsis cahni*	U.S.A. (TN, VA)	......do	T	28	17.95(e)	17.44(c)
Chub, Sonora	*Gila ditaenia*	U.S.A., (AZ), Mexico	......do	T	227	17.95(e)	17.44(o)
Chub, spotfin	*Hybopsis monacha*	U.S.A. (AL, GA, NC, TN, VA)	......do	T	28	17.95(e)	17.44(c)
Chub, Yaqui	*Gila purpurea*	U.S.A. (AZ), Mexico	......do	E	157	17.95(e)	NA
Cicek (minnow)	*Acanthorutilus handlirschi*	Turkey	......do	E	3	NA	NA
Cui-ui	*Chasmistes cujus*	U.S.A. (NV)	......do	E	1	NA	NA
Dace, Ash Meadows speckled	*Rhinichthys osculus nevadensis*	......do	......do	E	117E, 127E, 130	17.95(e)	NA
Dace, desert	*Eremichthys acros*	......do	......do	T	210	17.95(e)	17.44(m)
Dace, Foskett speckled	*Rhinichthys osculus ssp*	U.S.A. (OR)	......do	T	174	NA	17.44(j)
Dace, Kendall Warm Springs	*Rhinichthys osculus thermalis*	U.S.A. (WY)	......do	E	2	NA	NA
Dace, Moapa	*Moapa coriacea*	U.S.A. (NV)	......do	E	1	NA	NA
Darter, amber	*Percina antesella*	U.S.A. (GA, TN)	......do	E	198	17.95(e)	NA
Darter, bayou	*Etheostoma rubrum*	U.S.A. (MS)	......do	T	10	NA	17.44(b)
Darter, fountain	*Etheostoma fonticola*	U.S.A. (TX)	......do	E	2	17.95(e)	NA
Darter, leopard	*Percina pantherina*	U.S.A. (AR, OK)	......do	T	31	17.95(e)	17.44(d)
Darter, Maryland	*Etheostoma sellare*	U.S.A. (MD)	......do	E	1	NA	NA
Darter, Niangua	*Etheostoma nianguae*	U.S.A. (MO)	......do	T	185	17.95(e)	17.44(k)
Darter, Okaloosa	*Etheostoma okaloosae*	U.S.A. (FL)	......do	E	6	NA	NA
Darter, slackwater	*Etheostoma boschungi*	U.S.A. (AL, TN)	......do	T	28	17.95(e)	17.44(c)
Darter, snail	*Percina tanasi*	U.S.A. (AL, GA, TN)	......do	T	12, 150	NA	NA
Darter, watercress	*Etheostoma nuchale*	U.S.A. (AL)	......do	E	2	NA	NA
Gambusia, Big Bend	*Gambusia gaigei*	U.S.A. (TX)	......do	E	1	NA	NA
Gambusia, Clear Creek	*Gambusia heterochir*	......do	......do	E	1	NA	NA
Gambusia, Amistad	*Gambusia amistadensis*	......do	......do	E	93	NA	NA
Gambusia, Pecos	*Gambusia nobilis*	U.S.A. (NM, TX)	......do	E	2	NA	NA
Gambusia, San Marcos	*Gambusia georgei*	U.S.A. (TX)	......do	E	98	17.95(e)	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Killifish, Pahrump	*Empetrichthys latos*	U.S.A. (NV)	...do	E	1	NA	NA
Logperch, Conasauga	*Percina jenkinsi*	U.S.A. (GA, TN)	...do	E	196	17.95(e)	NA
Madtom, Scioto	*Noturus trautmani*	U.S.A. (OH)	...do	E	10	NA	NA
Madtom, Smoky	*Noturus baileyi*	U.S.A. (TN)	...do	E	163	17.95(e)	NA
Madtom, yellowfin	*Noturus flavipinnis*	U.S.A. (GA, TN, VA)	...do	T	28	17.95(e)	17.44(c)
Nekogigi (catfish)	*Coreobagrus ichikawai*	Japan	...do	E	3	NA	NA
Pupfish, Ash Meadows Amargosa	*Cyprinodon nevadensis mionectes*	U.S.A. (NV)	...do	E	117E, 127E, 130	17.95(e)	NA
Pupfish, Comanche Springs	*Cyprinodon elegans*	U.S.A. (TX)	...do	E	1	NA	NA
Pupfish, desert	*Cyprinodon macularius*	U.S.A. (AZ, CA) Mexico	...do	E	222	17.95(e)	NA
Pupfish, Devils Hole	*Cyprinodon diabolis*	U.S.A. (NV)	...do	E	1	NA	NA
Pupfish, Leon Springs	*Cyprinodon bovinus*	U.S.A. (TX)	...do	E	102	17.95(e)	NA
Pupfish, Owens	*Cyprinodon radiosus*	U.S.A. (CA)	...do	E	1	NA	NA
Pupfish, Warm Springs	*Cyprinodon nevadensis pectoralis*	U.S.A. (NV)	...do	E	2	NA	NA
Shiner, beautiful	*Notropis formosus*	U.S.A. (AZ, NM), Mexico	...do	T	157	17.95(e)	17.44(g)
Spikedace	*Meda fulgida*	...do	...do	T	236	NA	17.44(p)
Spinedace, Big Spring	*Lepidomeda mollispinis pratensis*	U.S.A. (NV)	...do	T	173	17.95(e)	17.44(l)
Spinedace, White River	*Lepidomeda albivallis*	...do	...do	E	203	17.95(e)	NA
Springfish, Hiko White River	*Crenichthys baileyi grandis*	...do	...do	E	206	17.95(e)	NA
Springfish, Railroad Valley	*Crenichthys nevadae*	...do	...do	T	224	17.95(e)	17.44(n)
Springfish, White River	*Crenichthys baileyi baileyi*	...do	...do	E	206	17.95(e)	NA
Squawfish, Colorado	*Ptychocheilus lucius*	U.S.A. (AZ, CA, CO, NM, NV, UT, WY), Mexico.	Entire, except Salt and Verde R. drainages, AZ.	E	1, 193	NA	NA
Do	...do	...do	Salt and Verde R. drainages, AZ.	XN	193	NA	17.84(b)
Stickleback, unarmored threespine	*Gasterosteus aculeatus williamsoni*	U.S.A. (CA)	Entire	E	2	NA	NA
Sturgeon, shortnose	*Acipenser brevirostrum*	U.S.A. and Canada (Atlantic Coast)	...do	E	1	NA	NA
Sucker, June	*Chasmistes liorus*	U.S.A. (UT)	...do	E	223	17.95(e)	NA
Sucker, Modoc	*Catostomus microps*	U.S.A. (CA)	...do	E	184	17.95(e)	NA
Sucker, Warner	*Catostomus warnerensis*	U.S.A. (OR)	...do	T	205	17.95(e)	17.44(l)
Tango, Miyako (Tokyo bitterling)	*Tanakia tanago*	Japan	...do	E	3	NA	NA
Temolek, Ikan (minnow)	*Probarbus jullieni*	Thailand, Cambodia, Vietnam, Malaysia, Laos.	...do	E	15	NA	NA
Topminnow, Gila	*Poeciliopsis occidentalis*	U.S.A. (AZ, NM), Mexico	...do	E	1	NA	NA
Totoaba (seatrout or weakfish)	*Cynoscion macdonaldi*	Mexico (Gulf of California)	...do	E	45	NA	NA
Trout, Apache	*Salmo apache*	U.S.A. (AZ)	...do	T	1, 8	NA	17.44(a)
Trout, Gila	*Salmo gilae*	U.S.A. (AZ, NM)	...do	E	1	NA	NA
Trout, greenback cutthroat	*Salmo clarki stomias*	U.S.A. (CO)	...do	T	1, 38	NA	17.44(l)
Trout, Lahontan cutthroat	*Salmo clarki henshawi*	U.S.A. (CA, NV)	...do	T	2, 8	NA	17.44(a)
Trout, Little Kern golden	*Salmo aguabonita whitei*	U.S.A. (CA)	...do	T	37	17.95(e)	17.44(e)
Trout, Paiute cutthroat	*Salmo clarki seleniris*	...do	...do	T	1, 8	NA	17.44(a)

Woundfin	*Plagopterus argentissimus*	U.S.A. (AZ, NV, UT)	Entire, except Gila R. drainage, AZ, NM.	E	2, 193	NA	NA
Do	...do	...do	Gila R. drainage AZ, NM.	XN	193	NA	17.84(b)
SNAILS							
Snail, Chittenango ovate amber	*Succinea chittenangoensis*	U.S.A. (NY)	NA	T	41	NA	NA
Snail, flat spired three toothed	*Triodopsis platysayoides*	U.S.A. (WV)	NA	T	[illegible]	[illegible]	[illegible]
Snail, Iowa Pleistocene	*Discus macclintocki*	[illegible]					

Trout, Paiute cutthroat	*Salmo clarki seleniris*	do					
Woundfin	*Plagopterus argentissimus*	U.S.A. (AZ, NV, UT)	Entire, except Gila R. drainage, AZ, NM.	E	2, 193	NA	NA
Do	do	do	Gila R. drainage AZ, NM.	XN	193	NA	17.84(b)
SNAILS							
Snail, Chittenango ovate amber	*Succinea chittenangoensis*	U.S.A. (NY)	NA	T	41	NA	NA
Snail, flat-spired three-toothed	*Triodopsis platysayoides*	U.S.A. (WV)	NA	T	41	NA	NA
Snail, Iowa Pleistocene	*Discus macclintocki*	U.S.A. (IA)	NA	E	41	NA	NA
Snail, Manus Island tree	*Papustyla pulcherrima*	Pacific Ocean: Admiralty Is. (Manus Is.)	NA	E	3	NA	NA
Snail, noonday	*Mesodon clarki nantahala*	U.S.A. (NC)	NA	T	41	NA	NA
Snail, Oahu tree	*Achatinella* spp. (all species)	U.S.A. (HI)	NA	E	108, 112	NA	NA
Snail, painted snake coiled forest	*Anguispira picta*	U.S.A. (TN)	NA	T	41	NA	NA
Snail, Stock Island	*Orthalicus reses* (not incl. *nesodryas*)	U.S.A. (FL)	NA	T	41	NA	NA
Snail, Virginia fringed mountain	*Polygyriscus virginianus*	U.S.A. (VA)	NA	E	41	NA	NA
CLAMS							
Pearly mussel, Alabama lamp	*Lampsilis virescens*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, Appalachian monkeyface	*Quadrula sparsa*	U.S.A. (TN, VA)	NA	E	15	NA	NA
Pearly mussel, birdwing	*Conradilla caelata*	do	NA	E	15	NA	NA
Pearly mussel, Cumberland bean	*Villosa* (=*Micromya*) *trabalis*	U.S.A. (KY, TN)	NA	E	15	NA	NA
Pearly mussel, Cumberland monkeyface	*Quadrula intermedia*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pearly mussel, Curtis'	*Epioblasma* (=*Dysnomia*) *florentina curtisi*	U.S.A. (MO)	NA	E	15	NA	NA
Pearly mussel, dromedary	*Dromus dromas*	U.S.A. (TN, VA)	NA	E	15	NA	NA
Pearly mussel, green-blossom	*Epioblasma* (=*Dysnomia*) *torulosa gubernaculum*	do	NA	E	15	NA	NA
Pearly mussel, Higgins' eye	*Lampsilis higginsi*	U.S.A. (IL, IA, MN, MO, NE, WI)	NA	E	15	NA	NA
Pearly mussel, Nicklin's	*Megalonaias nickliniana*	Mexico	NA	E	15	NA	NA
Pearly mussel, orange-footed	*Plethobasus cooperianus*	U.S.A. (AL, IN, IA, KY, OH, PA, TN)	NA	E	15	NA	NA
Pearly mussel, pale lilliput	*Toxolasma* (=*Carunculina*) *cylindrellus*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, pink mucket	*Lampsilis orbiculata*	U.S.A. (AL, IL, IN, KY, MO, OH, PA, TN, WV).	NA	E	15	NA	NA
Pearly mussel, Tampico	*Cyrtonaias tampicoensis tecomatensis*	Mexico	NA	E	15	NA	NA
Pearly mussel, tubercled-blossom	*Epioblasma* (=*Dysnomia*) *torulosa torulosa*.	U.S.A. (IL, IN, KY, TN, WV)	NA	E	15	NA	NA
Pearly mussel, turgid-blossom	*Epioblasma* (=*Dysnomia*) *turgidula*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, white cat's paw	*Epioblasma* (=*Dysnomia*) *sulcata delicata*	U.S.A. (IN, MI, OH)	NA	E	15	NA	NA
Pearly mussel, white wartyback	*Plethobasus cicatricosus*	U.S.A. (AL, IN, TN)	NA	E	15	NA	NA
Pearly mussel, yellow-blossom	*Epioblasma* (=*Dysnomia*) *florentina florentina*.	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pigtoe, fine-rayed	*Fusconaia cuneolus*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pigtoe, rough	*Pleurobema plenum*	U.S.A. (IN, KY, TN, VA)	NA	E	15	NA	NA
Pigtoe, shiny	*Fusconaia edgariana*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pocketbook, fat	*Potamilus* (=*Proptera*) *capax*	U.S.A. (AR, IN, MO, OH)	NA	E	15	NA	NA
Riffle shell, tan	*Epioblasma walkeri*	U.S.A. (KY, TN, VA)	NA	E	27	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Spiny mussel, Tar River	*Elliptio (Canthyria) steinstansana*	U.S.A. (NC)	NA	E	188	NA	NA
CRUSTACEANS							
Amphipod, Hay's Spring	*Stygobromus hayi*	U.S.A. (DC)	NA	E	115	NA	NA
Crayfish, Nashville	*Orconectes shoupi*	U.S.A. (TN)	NA	E	242	NA	NA
Isopod, Madison Cave	*Antrolana lira*	U.S.A. (VA)	NA	T	123	NA	17.46(a)
Isopod, Socorro	*Thermosphaeroma (=Exosphaeroma) thermophilus.*	U.S.A. (NM)	NA	E	36	NA	NA
Shrimp, Kentucky cave	*Palaemonias ganteri*	U.S.A. (KY)	NA	E	135	17.95(h)	NA
INSECTS							
Beetle, delta green ground	*Elaphrus viridis*	U.S.A. (CA)	NA	T	100	17.95(i)	NA
Beetle, valley elderberry longhorn	*Desmocerus californicus dimorphus*	do	NA	T	99	17.95(i)	NA
Butterfly, El Segundo blue	*Euphilotes (=Shijimiaeoides) battoides allyni.*	do	NA	E	14	NA	NA
Butterfly, Lange's metalmark	*Apodemia mormo langei*	do	NA	E	14	NA	NA
Butterfly, lotis blue	*Lycaeides argyrognomon lotis*	do	NA	E	14	NA	NA
Butterfly, mission blue	*Icaricia icarioides missionensis*	do	NA	E	14	NA	NA
Butterfly: Oregon silverspot	*Speyeria zerene hippolyta*	U.S.A. (OR, WA)	NA	T	95	17.95(i)	NA
Butterfly: Palos Verdes blue	*Glaucopsyche lygdamus palosverdesensis.*	U.S.A. (CA)	NA	E	98	17.95(i)	NA
Butterfly, San Bruno elfin	*Callophrys mossii bayensis*	do	NA	E	14	NA	NA
Butterfly, Schaus swallowtail	*Heraclides (=Papilio) aristodemus ponceanus.*	U.S.A. (FL)	NA	E	13,159	NA	NA
Butterfly, Smith's blue	*Euphilotes (=Shijimiaeoides) enoptes smithi.*	U.S.A. (CA)	NA	E	14	NA	NA
Moth, Kern primrose sphinx	*Euproserpinus euterpe*	do	NA	T	91	NA	NA
Naucorid, Ash Meadows	*Ambrysus amargosus*	U.S.A. (NV)	NA	T	181	17.95(i)	NA

EDITORIAL NOTE: For "When listed" citations, see list following; for symbols in "When listed" see below:
#—Indicates FR where species was delisted; relisting of the species is indicated by subsequent number(s).
E—Indicates Emergency rule publication (see FR document for effective dates); subsequent number(s) indicate FR final rule, if applicable under "When listed".

1—32 FR 4001; March 11, 1967.
2—35 FR 16047; October 13, 1970.
3—35 FR 8495; June 2, 1970.
4—35 FR 18320; December 2, 1970.
5—37 FR 6476; March 30, 1972.
6—38 FR 14678; June 4, 1973.
7—39 FR 44991; December 30, 1974.
8—40 FR 29864; July 16, 1975.
9—40 FR 31736; July 28, 1975.
10—40 FR 44151; September 25, 1975.
11—40 FR 44418; September 26, 1975.
12—40 FR 47506; October 9, 1975.
13—41 FR 17740; April 28, 1976.
14—41 FR 22044; June 1, 1976.
15—41 FR 24064; June 14, 1976.
16—41 FR 45993; October 19, 1976.
17—41 FR 51021; November 19, 1976.
18—41 FR 51612; November 23, 1976.
19—41 FR 53034; December 3, 1976.
20—42 FR 2076; January 10, 1977.
21—42 FR 2968; January 14, 1977.
22—42 FR 15971, March 24, 1977.
23—42 FR 28137; June 2, 1977.
24—42 FR 28545; June 3, 1977.
25—42 FR 37373; July 21, 1977.
26—42 FR 40685; August 11, 1977.
27—42 FR 42353; August 23, 1977.
28—42 FR 45528; September 9, 1977.
29—42 FR 58755; November 11, 1977.
30—42 FR 60745; November 29, 1977.
31—43 FR 3715; January 27, 1978.
32—43 FR 4028; January 31, 1978.
33—43 FR 4621; February 3, 1978.
34—43 FR 6233; February 14, 1978.
35—43 FR 9612; March 9, 1978.
36—43 FR 12691; March 27, 1978.
37—43 FR 15429; April 13, 1978.
38—43 FR 16345; April 18, 1978.
40—43 FR 20504; May 12, 1978.
41—43 FR 28932; July 3, 1978.
42—43 FR 32808; July 28, 1978.
43—43 FR 34479; August 4, 1978.
45—44 FR 21289; April 10, 1979.
46—44 FR 23064; April 17, 1979.
48—44 FR 29480; May 21, 1979.
50—44 FR 37126; June 25, 1979.
51—44 FR 37132; June 25, 1979.
52—44 FR 42911; July 20, 1979.
54—44 FR 49220; August 21, 1979.
55—44 FR 54007; September 17, 1979.
60—44 FR 59084; October 12, 1979.
85—44 FR 69208; November 30, 1979.
86—44 FR 70677; December 7, 1979.
87—44 FR 75076; December 18, 1979.
88—45 FR 18010; March 20, 1980.
90—45 FR 21833; April 2, 1980.
91—45 FR 24090; April 8, 1980.
92—45 FR 27713; April 23, 1980.
93—45 FR 28722; April 30, 1980.
94—45 FR 35821; May 28, 1980.
95—45 FR 44935; July 2, 1980.
96—45 FR 44939; July 2, 1980.
97—45 FR 47352; July 14, 1980.
98—45 FR 47355; July 14, 1980.
99—45 FR 52803; August 8, 1980.
100—45 FR 52807; August 8, 1980.
102—45 FR 54678; August 15, 1980.
103—45 FR 55654; August 20, 1980.
105—45 FR 63812; September 25, 1980.
106—45 FR 65132; October 1, 1980.
108—46 FR 3178; January 13, 1981.
111—46 FR 11665; February 10, 1981.
112—46 FR 40025; August 6, 1981.
113—46 FR 40664; August 10, 1981.
114—47 FR 4204; January 28, 1982.
115—47 FR 5425; February 5, 1982.
117—47 FR 19995; May 10, 1982.
119—47 FR 31670; July 21, 1982.
123—47 FR 43701; October 4, 1982.
124—47 FR 43962; October 5, 1982.
125—47 FR 46093; October 15, 1982.
127—48 FR 612; January 5, 1983.
128—48 FR 1726; January 14, 1983.
129—48 FR 28464; June 22, 1983.
130—48 FR 40184; September 2, 1983.
131—48 FR 43043; September 21, 1983.
132—48 FR 46057; October 11, 1983.
134—48 FR 46336; October 12, 1983.
135—48 FR 46341; October 12, 1983.
136—48 FR 49249; October 25, 1983.
137—49 FR 1058; January 9, 1984.
138—49 FR 1994; January 17, 1984.
139—49 FR 2783; January 23, 1984.
142—49 FR 7335; February 28, 1984.
143—49 FR 7394; February 29, 1984.
144—49 FR 7398; February 29, 1984.
145—49 FR 10526; March 20, 1984.
146—49 FR 14356; April 11, 1984.
149—49 FR 22334; May 29, 1984.
150—49 FR 27514; July 5, 1984.
156—49 FR 33885; August 27, 1984.
157—49 FR 34494; August 31, 1984.
159—49 FR 34504; August 31, 1984.
160—49 FR 34510; August 31, 1984.
161—49 FR 35954; September 13, 1984.
163—49 FR 43069; October 26, 1984.
164—49 FR 43969; November 1, 1984.
166—49 FR 45163; November 15, 1984.
168—49 FR 49639; December 21, 1984.
169—50 FR 1056; January 9, 1985.
170—50 FR 4226; January 30, 1985.
171—50 FR 4945; February 4, 1985.
173—50 FR 12302; March 28, 1985.
174—50 FR 12305; March 28, 1985.
181—50 FR 20785; May 20, 1985.
182—50 FR 21792; May 28, 1985.
183—50 FR 23884; June 6, 1985.
184—50 FR 24530; June 11, 1985.
185—50 FR 24653; June 12, 1985.
186—50 FR 25678; June 20, 1985.
188—50 FR 26575; June 27, 1985.
189—50 FR 27002; July 1, 1985.
193—50 FR 30194; July 24, 1985.
195—50 FR 31596; August 5, 1985.
196—50 FR 31603; August 5, 1985.
203—50 FR 37198; September 12, 1985.
205—50 FR 39117; September 27, 1985.
206—50 FR 39123; September 27, 1985.
210—50 FR 50308; December 10, 1985.
211—50 FR 50733; December 11, 1985.
212—50 FR 51252; December 16, 1985.
216—51 FR 6690; February 25, 1986.
222—51 FR 10850; March 31, 1986.

223—51 FR 10857; March 31, 1986.
224—51 FR 10864; March 31, 1986.
227—51 FR 16047: April 30, 1986.
228—51 FR 16482; May 2, 1986.
233—51 FR 17980; May 16, 1986.
236—51 FR 23781; July 1, 1986.
239—51 FR 27495; July 31, 1986.
241—51 FR 31422; September 3, 1986.
242—51 FR 34412; September 26, 1986.
246—51 FR 34425; September 26, 1986.

[48 FR 34182, July 27, 1983; 48 FR 34961, Aug. 2, 1983, as amended at 48 FR 39943, Sept. 2, 1983; 48 FR 46337, Oct. 12, 1983; 48 FR 52743, Nov. 22, 1983; 49 FR 1058, Jan. 9, 1984; 49 FR 33892, Aug. 27, 1984]

EDITORIAL NOTE: For additional FEDERAL REGISTER citations affecting the table in § 17.11(h), see the listing which follows the table.

EFFECTIVE DATE NOTE: At 51 FR 34412, 34425, Sept. 26, 1986, the table in § 17.11(h) was amended by adding "Shrew, Dismal Swamp southeastern" alphabetically under "Mammals" and adding "Crayfish, Nashville" alphabetically under "Crustaceans", effective October 27, 1986.

§ 17.12 Endangered and threatened plants.

(a) The list in this section contains the names of all species of plants which have been determined by the Services to be Endangered or Threatened. It also contains the names of species of plants treated as Endangered or Threatened because they are sufficiently similar in appearance to Endangered or Threatened species (see § 17.50 *et seq.*).

(b) The columns entitled "Scientific name" and "Common name" define the species of plant within the meaning of the Act. Although common names are included, they cannot be relied upon for identification of any specimen, since they may vary greatly in local usage. The Services shall use the most recently accepted scientific name. In cases in which confusion might arise, a synonym(s) will be provided in parentheses. The Services shall rely to the extent practicable on the *International Code of Botanical Nomenclature.*

(c) In the "Status" column the following symbols are used: "E" for Endangered, "T" for Threatened, and "E [or T] (S/A)" for similarity of appearance species.

(d) The other data in the list are nonregulatory in nature and are provided for the information of the reader. In the annual revision and compilation of this title, the following information may be amended without public notice: the spelling of species' names, historical range, footnotes, references to certain other applicable portions of this title, synonyms, and more current names. In any of these revised entries, neither the species, as defined in paragraph (b) of this section, nor its status may be changed without following the procedures of Part 424 of this title.

(e) The "Historic range" indicates the known general distribution of the species or subspecies as reported in the current scientific literature. The present distribution may be greatly reduced from this historic range. This column does not imply any limitation on the application of the prohibitions in the Act or implementing rules. Such prohibitions apply to all individuals of the plant species, wherever found.

(f)(1) A footnote to the FEDERAL REGISTER publication(s) listing or reclassifying a species is indicated under the column "When listed." Footnote numbers to §§ 17.11 and 17.12 are in the same numerical sequence, since plants and animals may be listed in the same FEDERAL REGISTER document. That document, at least since 1973, includes a statement indicating the basis for the listing, as well as the effective date(s) of said listing.

(2) The "Special rules" and "Critical habitat" columns provide a cross reference to other sections in Parts 17, 222, 226, or 227. The "Special rules" column will also be used to cite the special rules which describe experimental populations and determine if they are essential or nonessential. Separate listings will be made for experimental populations, and the status column will include the following symbols: "XE" for an essential experimental population and "XN" for a nonessential experimental population. The term "NA" (not applicable) appearing in either of these two columns indicates that there are no special rules and/or critical habitat for that particular species. However, all other appropriate rules in Parts 17, 217 through 227, and 402 still apply to that species. In addition, there may be other rules in this title that relate to

Species: Scientific name	Species: Common name	Historic range	Status	When listed	Critical habitat	Special rules
Agavaceae—Agave family:						
Agave arizonica	Arizona agave	U.S.A. (AZ)	E	147	NA	NA
Alismataceae—Water-plantain family:						
Sagittaria fasciculata	Bunched arrowhead	U.S.A. (NC, SC)	E	53	NA	NA
Amaranthaceae—Amaranth family:						
Achyranthes rotundata	None	U.S.A. (HI)	E	220	NA	NA
Annonaceae—Custard-apple family:						
Asimina tetramera	Four-petal pawpaw	U.S.A. (FL)	E	244	NA	NA
Deeringothamnus pulchellus	Beautiful pawpaw	do	E	244	NA	NA
Deeringothamnus rugelii	Rugel's pawpaw	do	E	244	NA	NA
Apiaceae—Parsley family:						
Oxypolis canbyi	Canby's dropwort	U.S.A. (DE, GA, MD, NC, SC).	E	217	NA	NA
Apocynaceae—Dogbane family:						
Cycladenia humilis var. *jonesii*	Jones cycladenia	U.S.A. (AZ, UT)	T	229	NA	NA
Asteraceae—Aster family:						
Argyroxiphium sandwicense ssp. *sandwicense*	'Ahinahina (Mauna Kea silversword)	U.S.A. (HI)	E	219	NA	NA
Bidens cuneata	Cuneate bidens	do	E	141	NA	NA
Chrysopsis floridana (=*Heterotheca floridana*)	Florida golden aster	U.S.A. (FL)	E	232	NA	NA
Dyssodia tephroleuca	Ashy dogweed	U.S.A. (TX)	E	152	NA	NA
Echinacea tennesseensis	Tennessee purple coneflower	U.S.A. (TN)	E	49	NA	NA
Enceliopsis nudicaulis var. *corrugata*	Ash Meadows sunray	U.S.A. (NV)	T	181	17.96(a)	NA
Erigeron maguirei var. *maguirei*	Maguire daisy	U.S.A. (UT)	E	202	NA	NA
Erigeron rhizomatus	Rhizome fleabane	U.S.A. (NM)	T	177	NA	NA
Grindelia fraxinopratensis	Ash Meadows gumplant	U.S.A. (CA, NV)	T	181	17.96(a)	NA
Hymenoxys texana	None	U.S.A. (TX)	E	218	NA	NA
Lipochaeta venosa	do	U.S.A. (HI)	E	73	NA	NA
Pityopsis ruthii (=*Heterotheca ruthii*, =*Chrysopsis ruthii*)	Ruth's golden aster	U.S.A. (TN)	E	191	NA	NA
Senecio franciscanus	San Francisco Peaks groundsel	U.S.A. (AZ)	T	137	17.96(a)	NA
Solidago shortii	Short's goldenrod	U.S.A. (KY)	E	201	NA	NA
Solidago spithamaea	Blue Ridge goldenrod	U.S.A. (NC, TN)	T	175	NA	NA
Stephanomeria malheurensis	Malheur wire-lettuce	U.S.A. (OR)	E	126	17.96(a)	NA
Townsendia aprica	Last Chance townsendia	U.S.A. (UT)	T	200	NA	NA
Berberidaceae—Barberry family:						
Mahonia sonnei (=*Berberis s.*)	Truckee barberry	U.S.A. (CA)	E	78	NA	NA
Betulaceae—Birch family:						
Betula uber	Virginia round-leaf birch	U.S.A. (VA)	E	39	NA	NA

Boraginaceae—Borage family:						
Amsinckia grandiflora	Large-flowered fiddleneck	U.S.A. (CA)	E	179	17.96(a)	NA
Brassicaceae—Mustard family:						
Arabis mcdonaldiana	McDonald's rock-cress	U.S.A. (CA)	E	44	NA	NA
Erysimum capitatum var. *angustatum*	Contra Costa wallflower	do	E	39	17.96(a)	NA
Thelypodium stenopetalum	Slender-petaled mustard	do	E	156	NA	NA
Buxaceae—Boxwood family:						
Buxus vahlii	Vahl's boxwood	U.S.A. (PR)	E	197	NA	NA
Cactaceae—Cactus family:						

Berberidaceae—Barberry family:						
Mahonia sonnei (=*Berberis s.*)	Truckee barberry					
Betulaceae—Birch family:						
Betula uber	[illegible]inia round leaf birch	U.S.A. (VA)	E	39	NA	NA
Boraginaceae—Borage family:						
Amsinckia grandiflora	Large-flowered fiddleneck	U.S.A. (CA)	E	179	17.96(a)	NA
Brassicaceae—Mustard family:						
Arabis mcdonaldiana	McDonald's rock-cress	U.S.A. (CA)	E	44	NA	NA
Erysimum capitatum var. *angustatum*	Contra Costa wallflower	....do	E	39	17.96(a)	NA
Thelypodium stenopetalum	Slender-petaled mustard	....do	E	158	NA	NA
Buxaceae—Boxwood family:						
Buxus vahlii	Vahl's boxwood	U.S.A. (PR)	E	197	NA	NA
Cactaceae—Cactus family:						
Ancistrocactus tobuschii (=*Echinocactus t., Mammillaria t.*)	Tobusch fishhook cactus	U.S.A. (TX)	E	80	NA	NA
Cereus eriophorus var. *fragrans*	Fragrant prickly-apple	U.S.A. (FL)	E	208	NA	NA
Cereus robinii	Key tree-cactus	U.S.A. (FL), Cuba	E	153	NA	NA
Coryphantha minima (=*C. nellieae, Escobaria n., Mammillaria n.*)	Nellie cory cactus	U.S.A. (TX)	E	81	NA	NA
Coryphantha ramillosa	Bunched cory cactus	U.S.A. (TX), Mexico (Coahuila).	T	77	NA	NA
Coryphantha robbinsorum (=*Cochiseia r., Escobaria r.*)	Cochise pincushion cactus	U.S.A. (AZ), Mexico (Sonora).	T	214	NA	NA
Coryphantha sneedii var. *leei* (=*Escobaria l., Mammillaria l.*)	Lee pincushion cactus	U.S.A. (NM)	T	61	NA	NA
Coryphantha sneedii var. *sneedii* (=*Escobaria s., Mammillaria s.*)	Sneed pincushion cactus	U.S.A. (TX, NM)	E	62	NA	NA
Echinocactus horizonthalonius var. *nicholii*	Nichol's Turk's head cactus	U.S.A. (AZ)	E	71	NA	NA
Echinocereus engelmannii var. *purpureus*	Purple-spined hedgehog cactus	U.S.A. (UT)	E	58	NA	NA
Echinocereus fendleri var. *kuenzleri* (=*E. kuenzleri, E. hempelii* of authors, not Fobe).	Kuenzler hedgehog cactus	U.S.A. (NM)	E	70	NA	NA
Echinocereus lloydii (=*E. roetteri* var. *l.*)	Lloyd's hedgehog cactus	U.S.A. (TX)	E	67	NA	NA
Echinocereus reichenbachii var. *albertii* (=*E. melanocentrus*)	Black lace cactus	....do	E	68	NA	NA
Echinocereus triglochidiatus var. *arizonicus* (=*E. arizonicus*)	Arizona hedgehog cactus	U.S.A. (AZ)	E	62	NA	NA
Echinocereus triglochidiatus var. *inermis* (=*E. coccineus* var. *i., E. phoeniceus* var. *i.*).	Spineless hedgehog cactus	U.S.A. (CO, UT)	E	83	NA	NA
Echinocereus viridiflorus var. *davisii* (=*E. davisii*)	Davis' green pitaya	U.S.A. (TX)	E	81	NA	NA
Neolloydia mariposensis (=*Echinocactus m., Echinomastus m.*)	Lloyd's Mariposa cactus	U.S.A. (TX), Mexico (Coahuila).	T	77	NA	NA
Pediocactus bradyi (=*Toumeya b.*)	Brady pincushion cactus	U.S.A. (AZ)	E	63	NA	NA
Pediocactus knowltonii (=*P. bradyi* var. *k. Toumeya k.*)	Knowlton cactus	U.S.A. (NM, CO)	E	72	NA	NA
Pediocactus peeblesianus var. *peeblesianus* (=*Echinocactus p., Navajoa p., Toumeya p., Utahia p.*).	Peebles Navajo cactus	U.S.A. (AZ)	E	69	NA	NA
Pediocactus sileri (=*Echinocactus s., Utahia s.*)	Siler pincushion cactus	U.S.A. (AZ, UT)	E	64	NA	NA
Sclerocactus glaucus (=*Echinocactus g., E. subglaucus, E. whipplei* var. *g., Pediocactus g., S. franklinii, S. whipplei* var. *g.*).	Uinta Basin hookless cactus	U.S.A. (CO, UT)	T	59	NA	NA
Sclerocactus mesae-verdae (=*Coloradoa m., Echinocactus m., Pediocactus m.*).	Mesa Verde cactus	U.S.A. (CO, NM)	T	75	NA	NA
Sclerocactus wrightiae (=*Pediocactus w.*)	Wright fishhook cactus	U.S.A. (UT)	E	58	NA	NA
Caryophyllaceae—Pink family:						
Schiedea adamantis	Diamond Head schiedea	U.S.A. (HI)	E	141	NA	NA

Nitrophila mohavensis	Amargosa niterwort					
Cistaceae—Rockrose family:						
Hudsonia montana	Mountain golden heather	U.S.A. (NC)	T	107	17.96(a)	NA
Crassulaceae—Stonecrop family:						
Dudleya traskiae	Santa Barbara Island liveforever	U.S.A. (CA)	E	39	NA	NA
Cucurbitaceae—Gourd family:						
Tumamoca macdougalii	Tumamoc globe-berry	U.S.A. (AZ), Mexico (Sonora).	E	226	NA	NA
Cupressaceae—Cypress family:						
Fitzroya cupressoides	Chilean false larch (=alerce)	Chile, Argentina	T	79	NA	NA
Cyperaceae—Sedge family:						
Carex specuicola	None	U.S.A. (AZ)	T	176	17.96(a)	NA
Ericaceae—Heath family:						
Arctostaphylos pungens var. *ravenii* (=*A. hookeri* ssp. *ravenii*)	Presidio (=Raven's) manzanita	U.S.A. (CA)	E	85	NA	NA
Rhododendron chapmanii	Chapman rhododendron	U.S.A. (FL)	E	47	NA	NA
Euphorbiaceae—Spurge family:						
Euphorbia (=*Chamaesyce*) *deltoidea* ssp. *deltoidea*	Spurge	U.S.A. (FL)	E	192	NA	NA
Euphorbia (=*Chamaesyce*) *garberi*	None	do	T	192	NA	NA
Euphorbia skottsbergii var. *kalaeloana*	Ewa Plains 'akoko	U.S.A. (HI)	E	120	NA	NA
Jatropha costaricensis	Costa Rican jatropha	Costa Rica	E	154	NA	NA
Fabaceae—Pea family:						
Amorpha crenulata	Crenulate lead-plant	U.S.A. (FL)	E	192	NA	NA
Astragalus humillimus	Mancos milk-vetch	U.S.A. (CO, NM)	E	187	NA	NA
Astragalus perianus	Rydberg milk-vetch	U.S.A. (UT)	T	39	NA	NA
Astragalus phoenix	Ash Meadows milk-vetch	U.S.A. (NV)	T	181	17.96(a)	NA
Baptisia arachnifera	Hairy rattleweed	U.S.A. (GA)	E	39	NA	NA
Galactia smallii	Small's milkpea	U.S.A. (FL)	E	192	NA	NA
Hoffmannseggia tenella	Slender rush-pea	U.S.A. (TX)	E	209	NA	NA
Lotus dendroideus ssp. *traskiae* (=*L. scoparius* ssp. *t.*)	San Clemente Island broom	U.S.A. (CA)	E	28	NA	NA
Mezoneuron kavaiense	Uhiuhi	U.S.A. (HI)	E	238	NA	NA
Vicia menziesii	Hawaiian vetch	do	E	38	NA	NA
Frankeniaceae—Frankenia family:						
Frankenia johnstonii	Johnston's frankenia	U.S.A. (TX), Mexico (Nuevo Leon).	E	155	NA	NA

Gentianaceae—Gentian family:						
Centaurium namophilum	Spring-loving centaury	U.S.A. (CA, NV)	T	181	17.96(a)	NA
Goodeniaceae—Goodenia family:						
Scaevola coriacea	Dwarf naupaka	U.S.A. (HI)	E	231	NA	NA
Hydrophyllaceae—Waterleaf family:						
Phacelia argillacea	Clay phacelia	U.S.A. (UT)	E	44	NA	NA
Phacelia formosula	North Park phacelia	U.S.A. (CO)	E	121	NA	NA

Viola menziesii						
Frankeniaceae—Frankenia family:						
Frankenia johnstonii	Johnston [illegible] enia	U.S.A. (TX), Mexico (Nuevo Leon).	E	165	NA	NA
Gentianaceae—Gentian family:						
Centaurium namophilum	Spring-loving centaury	U.S.A. (CA, NV)	T	181	17.96(a)	NA
Goodeniaceae—Goodenia family:						
Scaevola coriacea	Dwarf naupaka	U.S.A. (HI)	E	231	NA	NA
Hydrophyllaceae—Waterleaf family:						
Phacelia argillacea	Clay phacelia	U.S.A. (UT)	E	44	NA	NA
Phacelia formosula	North Park phacelia	U.S.A. (CO)	E	121	NA	NA
Lamiaceae—Mint family:						
Acanthomintha obovata ssp. *duttonii*	San Mateo thornmint	U.S.A. (CA)	E	204	NA	NA
Dicerandra cornutissima	Longspurred mint	U.S.A. (FL)	E	207	NA	NA
Dicerandra frutescens	Scrub mint	......do	E	207	NA	NA
Dicerandra immaculata	Lakela's mint	......do	E	180	NA	NA
Haplostachys haplostachya var. *angustifolia*	None	U.S.A. (HI)	E	73	NA	NA
Hedeoma apiculatum	McKittrick pennyroyal	U.S.A. (TX, NM)	T	118	17.96(a)	NA
Hedeoma todsenii	Todsen's pennyroyal	U.S.A. (NM)	E	110, 112	17.96(a)	NA
Pogogyne abramsii	San Diego mesa mint	U.S.A. (CA)	E	44	NA	NA
Scutellaria montana	Large-flowered skullcap	U.S.A. (GA,TN)	E	234	NA	NA
Stenogyne angustifolia var. *angustifolia*	None	U.S.A. (HI)	E	73	NA	NA
Lauraceae—Laurel family:						
Lindera melissifolia	Pondberry	U.S.A. (AL, AR, FL, GA, LA, MO, MS, NC, SC).	E	240	NA	NA
Liliaceae—Lily family:						
Erythronium propullans	Minnesota trout lily	U.S.A. (MN)	E	221	NA	NA
Harperocallis flava	Harper's beauty	U.S.A. (FL)	E	57	NA	NA
Trillium persistens	Persistent trillium	U.S.A. (GA, SC)	E	39	NA	NA
Loasaceae—Loasa family:						
Mentzelia leucophylla	Ash Meadows blazing star	U.S.A. (NV)	T	181	17.96(a)	NA
Malvaceae—Mallow family:						
Abutilon menziesii	Ko'oloa'ula	U.S.A. (HI)	E	243	NA	NA
Callirhoe scabriuscula	Texas poppy-mallow	U.S.A. (TX)	E	109, 112	NA	NA
Hibiscadelphus distans	Kauai hau kuahiwi	U.S.A. (HI)	E	225	NA	NA
Iliamna corei	Peter's Mountain mallow	U.S.A. (VA)	E	230	NA	NA
Kokia cookei	Cooke's kokio	U.S.A. (HI)	E	74	NA	NA
Kokia drynarioides	Koki'o (=hau-hele'ula or Hawaii tree cotton).	......do	E	167	17.96(a)	NA
Malacothamnus clementinus	San Clemente Island bush-mallow	U.S.A. (CA)	E	26	NA	NA
Sidalcea pedata	Pedate checker-mallow	......do	E	158	NA	NA
Nyctaginaceae—Four-o'clock family:						
Mirabilis macfarlanei	MacFarlane's four-o'clock	U.S.A. (ID, OR)	E	66	NA	NA

Onagraceae—Evening-primrose family:						
Camissonia benitensis	San Benito evening-primrose	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oenothera avita ssp. *eurekensis*	Eureka Valley evening-primrose	do	E	[illegible]	[illegible]	[illegible]
Oenothera deltoides ssp. *howellii*	Antioch Dunes evening primrose	do	E	39	17.96(a)	NA
Orchidaceae—Orchid family:						
Isotria medeoloides	Small whorled pogonia	U.S.A. (CT, IL, MA, MD, ME, MI, MO, NC, NH, NJ, NY, PA, RI, SC, VA, VT), Canada (Ont.).	E	122	NA	NA
Spiranthes parksii	Navasota ladies'-tresses	U.S.A. (TX)	E	116	NA	NA
Papaveraceae—Poppy family:						
Arctomecon humilis	Dwarf bear-poppy	U.S.A. (UT)	E	76	NA	NA
Pinaceae—Pine family:						
Abies guatemalensis	Guatemalan fir (=pinabete)	Mexico, Guatemala, Honduras, El Salvador.	T	84	NA	NA
Poaceae—Grass family:						
Tuctoria mucronata (=*Orcuttia m.*)	Solano grass	U.S.A. (CA)	E	44	NA	NA
Panicum carteri	Carter's panicgrass	U.S.A. (HI)	E	133	17.96(a)	NA
Swallenia alexandrae	Eureka Dune grass	U.S.A. (CA)	E	39	NA	NA
Zizania texana	Texas wild-rice	U.S.A. (TX)	E	39	17.96(a)	NA
Polygalaceae—Milkwort family:						
Polygala smallii	Tiny polygala	U.S.A. (FL)	E	192	NA	NA
Polygonaceae—Buckwheat family:						
Eriogonum gypsophilum	Gypsum wild-buckwheat	U.S.A. (NM)	T	110, 112	17.96(a)	NA
Eriogonum ovalifolium var. *williamsiae*	Steamboat buckwheat	U.S.A. (NV)	E	237	NA	NA
Eriogonum pelinophilum	Clay-loving wild-buckwheat	U.S.A. (CO)	E	161	17.96(a)	NA
Primulaceae—Primrose family:						
Primula maguirei	Maguire primrose	U.S.A. (UT)	T	199	NA	NA
Ranunculaceae—Buttercup family:						
Aconitum noveboracense	Northern wild monkshood	U.S.A. (IA, NY, OH, WI)	T	39	NA	NA
Clematis socialis	Alabama leather flower	U.S.A. (AL)	E	245	NA	NA
Delphinium kinkiense	San Clemente Island larkspur	U.S.A. (CA)	E	28	NA	NA
Rhamnaceae—Buckthorn family:						
Gouania hillebrandii	None	U.S.A. (HI)	E	165	17.96(a)	NA

Rosaceae—Rose family:						
Cowania subintegra	Arizona cliffrose	U.S.A. (AZ)	E	146	NA	NA
Ivesia eremica	Ash Meadows ivesia	U.S.A. (NV)	T	161	17.96(a)	NA
Potentilla robbinsiana	Robbins' cinquefoil	U.S.A. (NH, VT)	E	104	17.96(a)	NA
Rubiaceae—Coffee family:						
Gardenia brighamii	Na'u (Hawaiian gardenia)	U.S.A. (HI)	E	193	NA	NA
Rutaceae—Citrus family:						
[illegible]	St. Thomas prickly-ash	U.S.A. (PR, VI)	E	213	NA	NA

REFERENCE 15

Hanford Environmental Health Foundation

Drinking Water Report, HEHF-45

HANFORD SANITARY WATER SYSTEMS

During CY-1984, sanitary water was supplied on the Hanford Site by 17 individual drinking water systems, each consisting of a raw water supply, treatment facilities, and distribution piping. All of the systems are operated by Department of Energy contractors with the exception of the City of Richland municipal system which provides water to the 700, 1100, and 3000 Areas. Twelve of the systems utilize Columbia River water as a raw water source, four systems utilize groundwater, and one system (Richland municipal) a combination of the two. The systems range in size from those providing plant-scale treatment and serving extensive areas to nine systems which supply water to single or small complexes of facilities only.

The systems, along with their sources of supply, service areas, and additional pertinent information, are listed below. A Hanford Site map depicting locations of the systems (with the exception of the Richland municipal system) is given in Figure 1.

System	Source of Supply	Notes
100-B	Columbia River via 181-B Pumphouse	Filtered and chlorinated. Sanitary water supplied to 182-B Bldg. only. System is Rockwell (RHO) operated.
100-D	Columbia River via 181-D Pumphouse	Filtered and chlorinated at 183-D. Treated water also supplied to 100-F and 100-H Areas as needed. System is RHO operated.
100-K	Columbia River via 181-K Pumphouse	Filtered and chlorinated. System is United Nuclear Corporation (UNC) operated.
100-N	Columbia River via 181-N Pumphouse	Filtered and chlorinated. System is UNC operated.
200-E	Columbia River via 100-B raw water export	Filtered and chlorinated at 283-E. System is RHO operated.

REFERENCE 16

Draft Phase I Installation Assessment of Inactive Waste-Disposal Sites at Hanford, Volume 3

SITE ID NO.: Pickling Acid Crib

ALIAS: None

FACILITY: Crib

STATUS: Inactive

ELEVATION:

WATERTABLE:

DIMENSIONS:
- Length: 50 ft
- Width: 30 ft
- Depth: 10 ft
- Diameter: 0

LOCATION: 600 Area

COORDINATES: To be determined

SITE DESCRIPTION:

A crib type structure 50 feet by 30 feet and 10 feet deep located 500 yards from the old White Bluffs Ice Plant and 300 yards east of Federal Avenue. Vent pipes extrude every 18 inches at the surface.

SERVICE DATES: 1943 - 1945

SERVICE HISTORY:

The site was used to pickle galvanized piping for use in the reactor buildings during construction. The process used several thousand gallons of nitric and hydrofluoric acid. The site was retired in 1945 and the surface was covered with large cobbles.

REFERENCES:

Documents:

Photographs: 122440-464-CN, 122440-465-CN

Drawings:

SITE ID NO.: Pickling Acid Crib

CHEMICALS DISPOSED

No chemical inventory is available.

RADIONUCLIDE INVENTORY
(in curies)

H-3:	0.00000	CE-144:	0.00000
C-14:	0.00000	PR-144:	0.00000
MN-54:	0.00000	PM-147:	0.00000
CO-60:	0.00000	EU-152:	0.00000
NI-63:	0.00000	EU-154:	0.00000
KR-85:	0.00000	EU-155:	0.00000
SR-90:	0.00000	NP-237:	0.00000
Y-91:	0.00000	PU-238:	0.00000
NB-95:	0.00000	PU-239:	0.00000
ZR-95:	0.00000	PU-240:	0.00000
TC-99:	0.00000	PU-241:	0.00000
RU-103:	0.00000	AM-241:	0.00000
RU-106:	0.00000	U-233:	0.00000
SN-113:	0.00000	U-235:	0.00000
SB-125:	0.00000	U-238:	0.00000
I-129:	0.00000	TH-232:	0.00000
CS-134:	0.00000	BETA:	0.00000
CS-137:	0.00000	GAMMA:	0.00000
CE-141:	0.00000	ALPHA:	0.00000

This site was not used to deliberately dispose of radioactive waste.

These values are decayed through April 1, 1986.

SITE ID NO.: 107-B

DIMENSIONS: ELEVATION: 440 feet

WATERTABLE: 40 feet

Length: 450 feet
Width: 230 feet
Depth: 24 feet
Diameter:

FACILITY: Retention Basin

LOCATION: 100-B/C
COORDINATES: N71660/W80560, N71660/W80090, N71430/W80560, N71430/W80090

DESCRIPTION OF FACILITY

Concrete lined basin, 230 ft. x 467 ft., with a vertical baffle down the middle (lengthwise). The floor of the basin consists of concrete slabs, their joints originally closed with neoprene water seals. To a height of almost 10 ft. above the floor, the walls slope and are about 4 inches thick. The upper sections of the walls (about 10 ft) area vertical and range in thickness from about 5'8" at the bottom to one foot at the top.

The basin has been backfilled with soil to a depth of almost four feet.

DATE OF OPERATIONS: 1944-1968

DESCRIPTION OF WASTE

Retained cooling water effluent from the 105 reactor for radioactive decay and thermal cooling prior to release to the Columbia River. Total radionuclide inventories in the vicinity of the basins ranged from 5 to over 400 curies. 80% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

The following is a summary of unplanned releases in the basin area:
- In early 1952, gross leakage at the inlet for the 105-B effluent line was detected and steadily increased in volume.
- In late 1952, two known leaks from the effluent line occurred: (1) near the #2 diversion box for the 30" line and (2) near the 8" riser for the temporary by-pass line northeast of the 105-B Building.
- In February, 1954, a break occurred in the 107-B Basin.

EXTENT OF CONTAMINATION

The extent of the contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

Ref. 16.3

*** MEMO FIELD EMPTY ***

REFERENCES:

Documents: UNI-946

Photographs:

Drawings:

SITE ID NO.: 107-C

DIMENSIONS:

ELEVATION: 440 feet

WATERTABLE: 40 feet

Length:
Width:
Depth: 16 feet
Diameter: 330 feet

FACILITY: Retention Basins (2)

LOCATION: 100-B/C
COORDINATES: N-71045/W-79970, N-71045/W-80320

DESCRIPTION OF FACILITY

Two carbon steel tanks, each 330 feet in diameter and 16 feet deep. Each has a series of steel baffle plates inside to prevent water from channeling across the tank into the discharge line. Both tanks have been backfilled with soil to a depth of about four feet.

DATE OF OPERATIONS: 1942-1969

DESCRIPTION OF WASTE

Retained cooling water effluent from the 105 reactor for radioactive decay and thermal cooling prior to release to the Columbia River. Total radionuclide inventories in the vicinity of the basins ranged from 5 to over 400 curies. 80% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

The basin and its approximate 5 foot diameter effluent line has developed leaks during its operating life. It has been said the leaks could have been as high as 5,000 - 10,000 gallons per minute.

EXTENT OF CONTAMINATION

The extent of the contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

*** MEMO FIELD EMPTY ***

REFERENCES:
Documents: UNI-946

Photographs:

Ref. 16.5

Drawings: P-5242

Ref. 16.6

SITE ID NO.: 107-D

DIMENSIONS:

ELEVATION: 420 feet

WATERTABLE: 35 feet

Length: 450 feet
Width: 230 feet
Depth: 24 feet
Diameter:

FACILITY: Retention Basin

LOCATION: 100 D-DR
COORDINATES: N-94455/W-52730 to N-94685/W-53250

DESCRIPTION OF FACILITY

A concrete-lined basin, 230 ft. x 467 ft., with 20 foot walls. The design is about the same as 107-B. the basin has been backfilled to a depth of about 2 ft. The walls appear to be coated with asphalt.

DATE OF OPERATIONS: 1944-1967

DESCRIPTION OF WASTE

Retained reactor cooling water effluent water from the 105 reactor for radioactive decay and thermal cooling prior to release to the Columbia River. Total radionuclide inventories in the vicinity of the basins ranged from 5 to over 400 curies. 70% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

The following is a summary of unplanned releases in the basin area:
- In early 1950, leakage occurred on the north side between the basin and the river. Effluent water had drained under the road to the section between the road and the perimeter fence.
- In the fall of 1951, excess leakage was detected above ground. As a result, two excavations were made. The holes were then covered, but effluent water continued to seep to the surface.

EXTENT OF CONTAMINATION

The extent of the contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

*** MEMO FIELD EMPTY ***

Ref. 16.7

REFERENCES:

Documents: UNI-946

Photographs:

Drawings: M-1901-D Sh.8

Ref. 16.8

SITE ID NO.: 107-DR

DIMENSIONS:

ELEVATION: 420 feet

WATERTABLE: 35 feet

Length: 600 feet
Width: 230 feet
Depth:
Diameter:

FACILITY: Retention Basin

LOCATION: 100-D/DR
COORDINATES: N-94058/W52516, N94680/W52219

DESCRIPTION OF FACILITY

A concrete-lined basin, 230 ft. x 600 ft., with 20 foot walls. It has been backfilled to a depth of one to 3 feet.

DATE OF OPERATIONS: 1950-1964

DESCRIPTION OF WASTE

Retained cooling water effluent from the 105 reactor for radioactive decay and thermal cooling prior to release to the Columbia River. Total radionuclide inventories in the vicinity of the basins ranged from 5 to over 400 curies. 70% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

The following is a summary of unplanned releases in the basin area:
- In late 1951, extensive leakage of effluent water at the inlet end of the 107-DR retention basin was caused by the pipes pulling loose from the basin wall.

EXTENT OF CONTAMINATION

The extent of the contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

*** MEMO FIELD EMPTY ***

REFERENCES:
Documents: UNI-946

Photographs:

Drawings: M-1901-D Sh. 8

Ref. 16.10

SITE ID NO.: 107-F

DIMENSIONS:

ELEVATION: 400 feet

WATERTABLE: 30 feet

Length: 450 feet
Width: 230 feet
Depth: 24 feet
Diameter:

FACILITY: Retention Basin

LOCATION: 100-F
COORDINATES: N79967/W24130, N79967/W28900, N79500/W28900, N79500/W29130

DESCRIPTION OF FACILITY

A concrete-lined basin, 230 ft. x 467 ft., with 20 foot walls, similar in design to 100-B and 100-D. The basin has back-filled to a depth of about 5 feet, with soil piled to cover the walls.

DATE OF OPERATIONS: 1945-1965

DESCRIPTION OF WASTE

Retained cooling water effluent from the 105 reactor for radioactive decay and thermal cooling prior to releae to the Columbia River. 70% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

EXTENT OF CONTAMINATION

The extent of the contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

*** MEMO FIELD EMPTY ***

REFERENCES:
Documents: UNI-946

Photographs:

Drawings: M-1600-F Sh.5

Ref. 16.11

SITE ID NO.: 107-H

DIMENSIONS: ELEVATION: 420 feet

WATERTABLE: 10 feet

Length: 600 feet
Width: 273 feet
Depth: 20 feet
Diameter:

FACILITY: Retention Basin

LOCATION: 100-H
COORDINATES: N96000/W38740, N96000/W38466, N95368/W38466, N95368/W38740

DESCRIPTION OF FACILITY

Concrete-lined rectangular basin, 273 ft. x 600 ft.; 20 feet deep. The basin has been back-filled to a depth of about 4 feet above the floor and slopes to the top of the walls.

DATE OF OPERATIONS: 1949-1965

DESCRIPTION OF WASTE

Retained cooling water effluent from the 105 reactor for radioactive decay and thermal cooling prior to release to the Columbia River. 70% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

The basin and its approximate 5 foot diameter effluent line has developed leaks during its operating life. It has been said the leaks could have been as high as 5,000 - 10,000 gallons per minute.

EXTENT OF CONTAMINATION

The extent of contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

*** MEMO FIELD EMPTY ***

REFERENCES:
Documents: UNI-946

Photographs:

Drawings: M-1600-H Sh.4

Ref. 16.12

SITE ID NO.: 107-KE

DIMENSIONS:

ELEVATION: 480 feet

WATERTABLE: 70 feet

Length:
Width:
Depth: 29 feet
Diameter: 250 feet

FACILITY: Retention Basins (3)

LOCATION: 100-K
COORDINATES: N(K)565699/W426802, N(K)532850/W453651, N(K)53000/W480500

DESCRIPTION OF FACILITY

Three carbon steel tanks, 250 ft. in diameter and 29 ft. deep. They have been backfilled with soil to a depth of about 4 feet.

DATE OF OPERATIONS: 1955-1971

DESCRIPTION OF WASTE

Retained cooling water effluent from the 105 reactor for radioactive decay and thermal cooling prior to release to the Columbia River. 80% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

The basin and its approximate 5 foot diameter effluent line has developed leaks during its operating life. The leak rate from the butterfly valves (that went to an adjacent trench) could have been as high as 5,000-10,000 gallons per minute. Most of the basin leakage was diverted to an open canal and disposed to the river.

EXTENT OF CONTAMINATION

The extent of the contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

*** MEMO FIELD EMPTY ***

REFERENCES:
Documents: UNI-946

Photographs:

Drawings: H-1-25529

Ref. 16.13

SITE ID NO.: 107-KW

DIMENSIONS:

ELEVATION: 480 feet

WATERTABLE: 70 feet

Length:
Width:
Depth: 29 feet
Diameter: 250 feet

FACILITY: Retention Basins (3)

LOCATION: 100-K
COORDINATES: N(K)5245/W(K)6190, N(K)5245/W(K)6460, N(K)5245/W(K)6730

DESCRIPTION OF FACILITY

Three carbon steel tanks, 250 ft. in diameter and 29 ft. deep. They have been backfilled with soil to a depth of about 4 feet.

DATE OF OPERATIONS: 1944-1970

DESCRIPTION OF WASTE

Retained cooling water effluent from the 105 reactor for radioactive decay and thermal cooling prior to release to the Columbia River. 80% of the total radionuclide inventory is contained within the soil adjacent to the basins. Approximately 10 curies have leached into the concrete floor and walls.

UNPLANNED RELEASE

The basin and its approximate 5 foot diameter effluent line has developed leaks during its operating life. The leak rate form the butterfly valves (that went to an adjacent trench) could have been as high as 5,000-10,000 gallons per minute. Most of the basin leakage was diverted to an open canal and disposed to the river.

EXTENT OF CONTAMINATION

The extent of the contamination from these releases is well within the zone encompassed by the retention basin and is within the AC-5-40 permanent posting.

*** MEMO FIELD EMPTY ***

REFERENCES:
Documents: UNI-946

Photographs:

Ref. 16.14

Drawings: H-1-24429

Drawings: P-5242

Ref. 16.16

REFERENCE 17

File Memo regarding recreational use of the

Columbia River

Battelle
Pacific Northwest Laboratories

Project Number

Internal Distribution

KH Cramer
RD Stenner
File/LB

Date August 26, 1987

To IWSS Files

From DR Sherwood

Subject Recreational Use of Hanford Reach

The Hanford Reach of the Columbia River has many recreational uses. Sportsman's access for fishing and waterfowl, big game, and upland bird hunting is provided at several locations. Access points to the Columbia River along the Hanford Reach are located at the old White Bluffs Ferry landing, the Ringold Hatchery, and Leslie Grove Park in Richland. I have fished for steelhead and salmon along the Hanford Reach since 1980.

DRS/mgs

REFERENCE 18

Letter from RD Stenner to DM Bennett regarding 100 Area Ground Water Contaminant Plume, October 14, 1987

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509)
Telex 15-2874

October 14, 1987

Mr. D. M. Bennett
U.S. Environmental Protection Agency
Region X
Superfund Program
1200 6th Avenue
Seattle, WA 98101

Dear Dave:

Enclosed are the three descriptions of the 100 Area, 200 Area and 300 Area ground water contaminant plumes we discussed on the telephone yesterday. I have included some attached figures and maps to help show the independency of the detected ground water contamination in each of the three aggregate areas.

If there are any questions regarding the descriptions, please contact me at 509-375-2916.

Sincerely,

Bob

R.D. Stenner, Sr. Research Engr.
Earth and Environmental Sciences Center
GEOSCIENCES DEPARTMENT

RDS:th

100 Area Ground Water Contamination

The ground water chromium and strontium-90 concentrations in the 100 Area are attributable only to the activities in the 100 Area because of the isolation of these areas and the fact that several years of ground water monitoring in the area show that any concentrations in ground water are found contained in close proximity to each of the individual reactor sites. Upstream samples of the surface water show that the contamination detected downstream are attributable to activity in the 100 Area. The furthest downstream location of contaminants from the 100 Area entering the river is at river mile 22. The furthest upstream entry point of the 100 Area contaminants is just above river mile 2, which is near the 100 B/C Area.

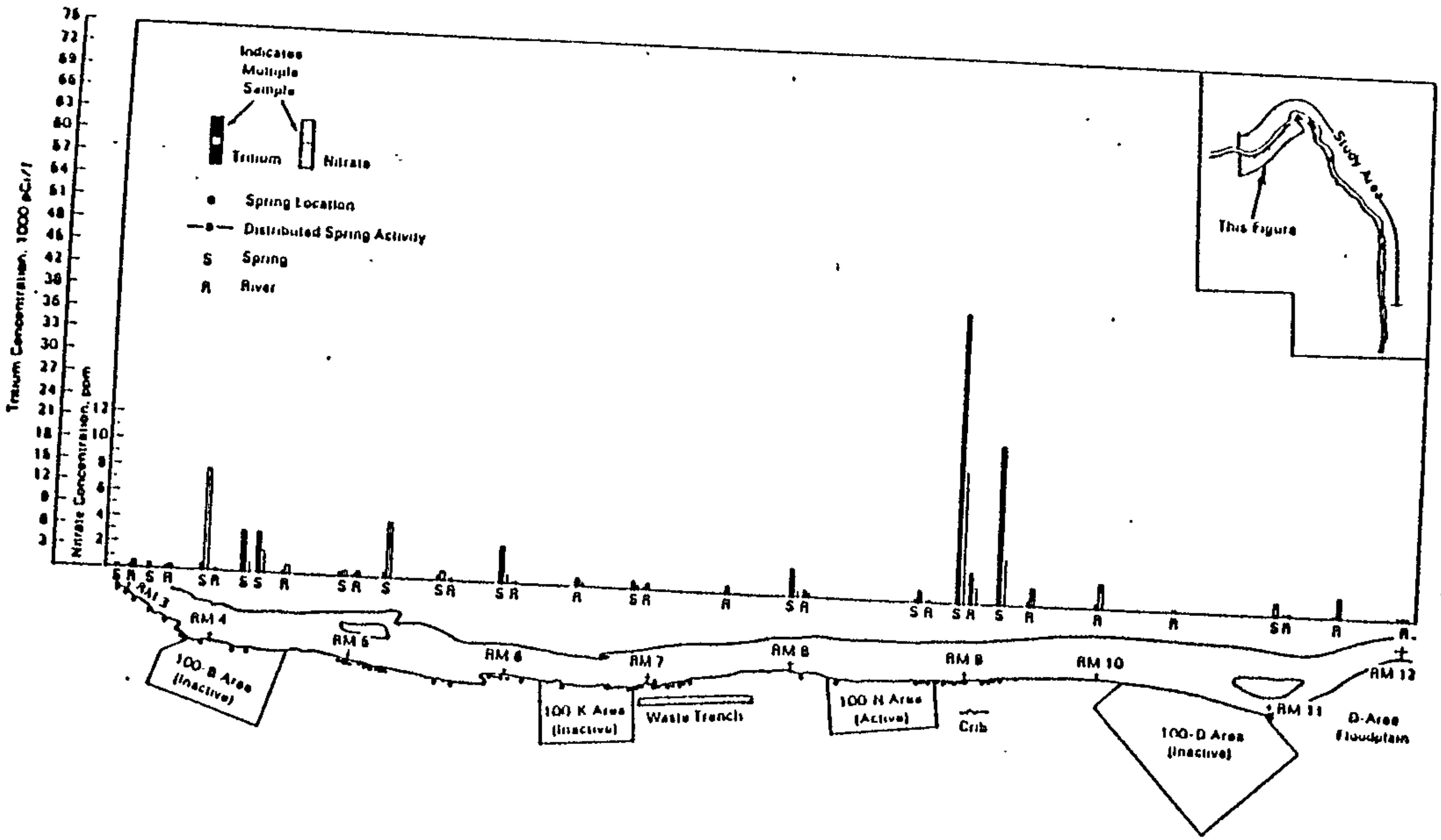

FIGURE 3. Locations and Analytical Results for Spring and River Samples from River Mile 3 through River Mile 12

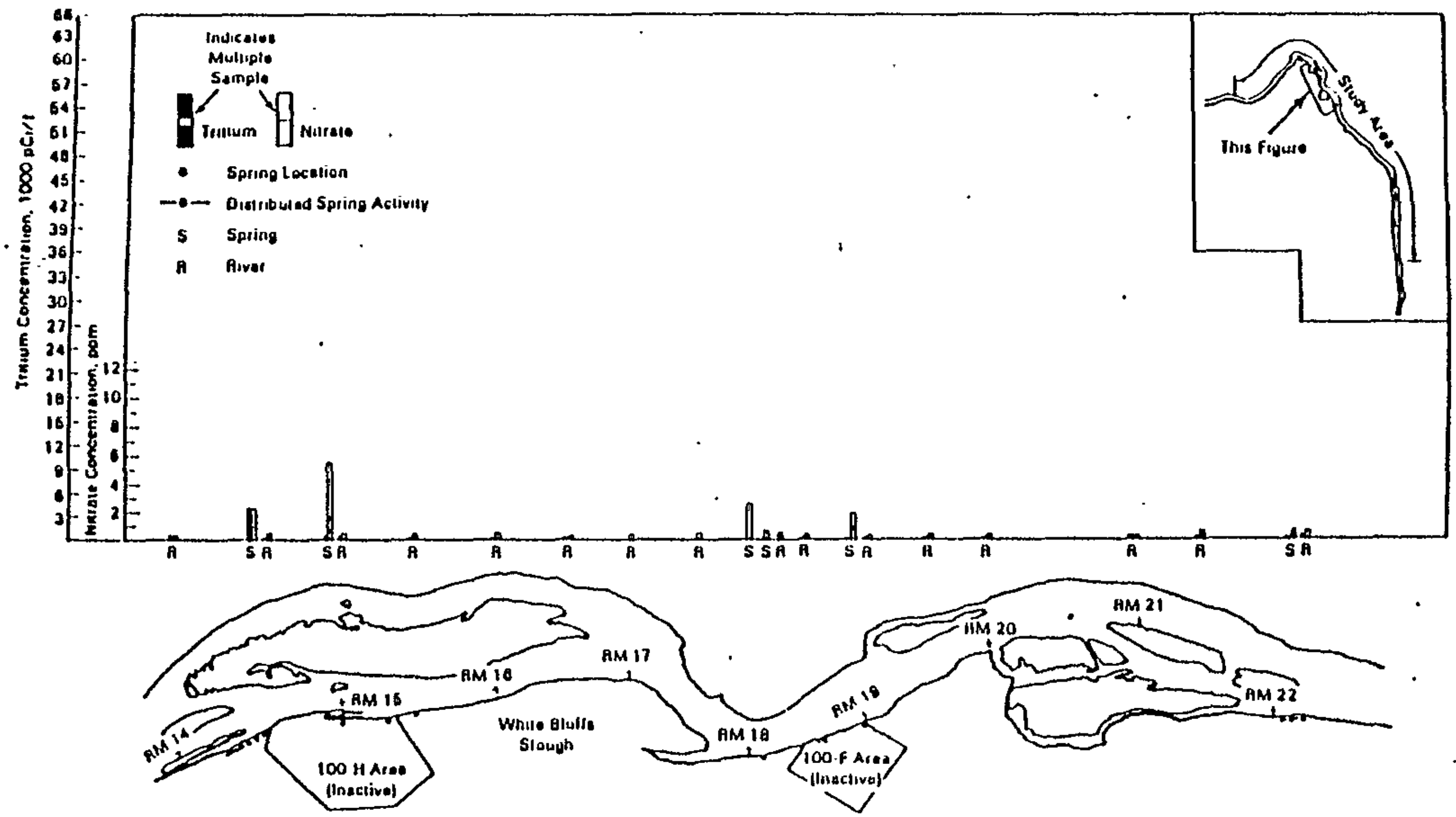

FIGURE 4. Locations and Analytical Results for Spring and River Samples from River Mile 14 through River Mile 22

REFERENCE 19

Letter from RD Stenner to DM Bennett regarding Liquid Waste Sites and Burning Pits, October 26, 1987

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509)
Telex 15-2874

October 26, 1987

D.M. Bennett
EPA/NPL Coordinator
EPA Superfund Program
U.S. Environmental Protection Agency Region X
1200 Sixth Ave.
Seattle, Washington 98101

Dear Dave:

Per your telephone request, enclosed are the statements on liquid waste sites and burning pits. It is our understanding that you will incorporate them as references in the appropriate sections of the NPL packages and provide us with a finalized copy of the packages following completion of the MITRE Corp. review.

If there are any questions regarding these statements, please don't hesitate to contact me at 509-375-2916.

Sincerely,

Bob

R.D. Stenner, Senior Research Engineer
Environmental Pathways and Assessment Section
Geosciences Department
Earth and Environmental Sciences Center

RDS:dar

ENCLOSURE

bcc: KH Cramer
MS Hanson
DA Lamar
RM Mangin - DOE/RL
TJ McLaughlin
RG Schreckhise
WB Schulze - DOE/RL
DR Sherwood

100, 200, 300 Area Statement Regarding Liquid Wastes

The general operating procedures for liquid waste sites in the 100, 200 and 300 Areas were such that the waste constituents listed for each site generally entered the process lines and were mixed with each other prior to being disposed of at the site. This process mixing of these waste constituents occurred over the period of site operation.

Burning Pit Statement

Due to the time period for which the burning pits operated, the nonhazardous combustible waste materials (i.e., paper products, cans, etc.) would have been mixed (i.e., mixed together in the garbage truck or waste container) with the hazardous waste materials (i.e., paints, solvents, etc.) prior to the waste mixture being disposed of at the site.

Reference 20

Memo from Kathleen Galloway, MITRE, to Sandy Crystall, EPA
December 29, 1987

Reference 20

MITRE

To: Sandy Crystall, Acting Chief for NPL Operations, Environmental Protection Agency (EPA)

Date: 29 December 1987

From: Kathleen Galloway, Member of the Technical Staff, The MITRE Corporation

Subject: The Toxicity of Uranium and Plutonium

Copies: B. Myers, S. Parrish

According to Sax, uranium is a highly toxic element on an acute basis as well as on a ratio-toxic basis. For this reason the Agency feels it is appropriate to assign a value of three for the toxicity of uranium.

Sax states that the toxicity of plutonium compounds is based first upon the very high radio-toxicity of the plutonium atom. In addition, the permissible levels for plutonium are the lowest for any radioactive element. Therefore, although a method for assigning toxicity values for radio-nuclides is not established, the language in Sax would appear to justify a toxicity value of 3 for plutonium.

KG/js

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